Assessment of Fast Radiographic Systems by the Constant Exposure Technique

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ASSESSMENT OF FAST RADIOGRAPHIC SYSTEMS BY THE CONSTANT EXPOSURE TECHNIQUE

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Abstract. The constant exposure technique was applied to compare the radiographic image quality and relative speed of different fast radiographic systems. Conventional industrial X-ray films, exposed with lead intensifying screens, special fast film with fluorometallic screens as well as different brands of radiographic paper exposed both with fluorescent as well as fluorometalllic screens were tested and compared. ISO wire IQI's and ASTM penetrameters were used together with 30-mm aluminium and 10-mm steel plates. For all the fast radiographic systems wire sensitivity better than 2% was obtained. The constant exposure technique proved to be adequate for the assessment of fast radiographic systems.

INIS Descriptors: INDUSTRIAL RADIOGRAPHY; PAPER; PHOTOGRAPHIC FILMS; QUALITY CONTROL; X-RAY RADIOGRAPHY

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ASSESSMENT OF FAST RADIOGRAPHIC SYSTEMS BY THE CONSTANT EXPOSURE TECHNIQUE

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1. INTRODUCTION

The constant exposure technique, already described in [1] was investigated further in [2] and proved to be useful for such fast radiographic systems as radiographic paper used both with fluorescent as well as fluorometallic intensifying screens.

Recently, Agfa-Gevaert put on the market a new, fast X-ray film: Structurix RCF, high-contrast film, specially designed for use with fluorometallic intensifying screens.

This new, fast X-ray film together with fast radiographic papers was described in [3].

The constant exposure technique seems especially suitable for making comparisons between different radiographic systems and was therefore used for the assessment of the fast radiographic systems mentioned above.

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* Work performed under contract with Risø National Laboratory.

2. RADIOGRAPHIC PAPER

The present comparisons of various fast radiographic systems was made, using the following radiographic papers, available now on the market:

- Kodak Industrex Instant 600, Rapid 620 and 700 papers, used with Kodak fluorescent F1 (high-speed, high-contrast) and F2 (smaller intensification, lower contrast) Industrex intensifying screens.
- Agfa-Gevaert Structurix IC paper used with a fluorescent IC screen Type II and with fluorometallic RCF screen.

Both Kodak as well as Agfa-Gevaert radiographic papers were processed in their respective automatic processors, previously described in [4].
The radiographic paper can be used both with fluoroscent and with fluorometallic screens. This was proved and reported in [5]. This fast radiographic system was therefore also included into the present assessment.

3. FAST X-RAY FILMS

The above-mentioned Agfa-Gevaert Structurix RCF film was used with RCF fluorometallic screens (FM). This film is sensitive to X- and gamma-rays, UV-, violet and blue rays, and to rays emitted by the fluorometallic screens. The spectral sensitivities of Structurix IC paper, RCF film and FM screens was reproduced in [5].

Agfa-Gevaert allows the processing of the RCF film in the same manner as all other Structurix films. When using conventional manual processing the G 127 developer (concentration: 1 part of G 127 + 4 parts of water) is to be used for developing at 20°C for 5 min. Rapid processing is also possible and even recommended. For rapid manual processing the G 127 developer in (1 + 1) concentration is to be used at 35°C for 45 s (with

continuous agitation). For rapid machine processing the G 127/G 135 developers are to be used at 42°C. As no Structurix automatic machine processors were available in Denmark, some automatic processing of the RCF film was performed using the Rapiline 63 processor, made available for that purpose by the Agfa-Gevaert A/S in Glostrup, Denmark. In this automatic processor the RCF film was developed at 35°C for 32 s in a (1 + 3) concentrated G 137 developer. This automatic processing gave, however, very inconsistent results and therefore was not used further.

Thus the RCF film was normally developed for 5 min at 20°C in the (1 + 4) G 127 developer and for 45 s at 35°C in the (1+1) G 127.

For the sake of comparison two brands of the conventional industrial fast X-ray films were used: the Kodak Industrex D and Agfa-Gevaert Structurix D 10. Both were used with 0.05 + 0.10 mm lead intensifying screens (above 50 kV) or without screens (below 50 kV). They were manually processed: the Kodak D film in the DX-80 developer for 4 min at 20°C (1+4 concentration) and the Agfa-Gevaert D10 film for 5 min at 20°C in the G 127 developer (1 + 5 concentration).

4. COMPARISON BETWEEN X-RAY FILM AND RADIOGRAPHIC PAPER

Comparisons between X-ray film and paper were already previously made |6,7| using radiographic papers available at that time. In the present report the assessment will be made using radiographic papers mentioned in 2 above.

All the above mentioned investigations made with radiographic paper and fast X-ray films have shown the following advantages of those fast radiographic systems:

- Shorter exposure times due to the higher speed of the system.

- Lower material costs for paper radiography.
- Shorter processing times, especially with automatic processors.
- Lower labor costs due to shorter exposure and processing times.
- Lower equipment costs due to lower kilovoltages in use.
- Easier radiation protection due to lower kilovoltages in use.

5. X-RAY MACHINES

The investigation was performed using Andrex 180 and 300 kV self-rectified, single-tank machines.

Fig. 1 shows the 180 kV machine used for radiography of the 30-mm Al plate, whereas on fig. 2 the 300 kV machine is shown, used for radiography of the 10-mm Fe plate.

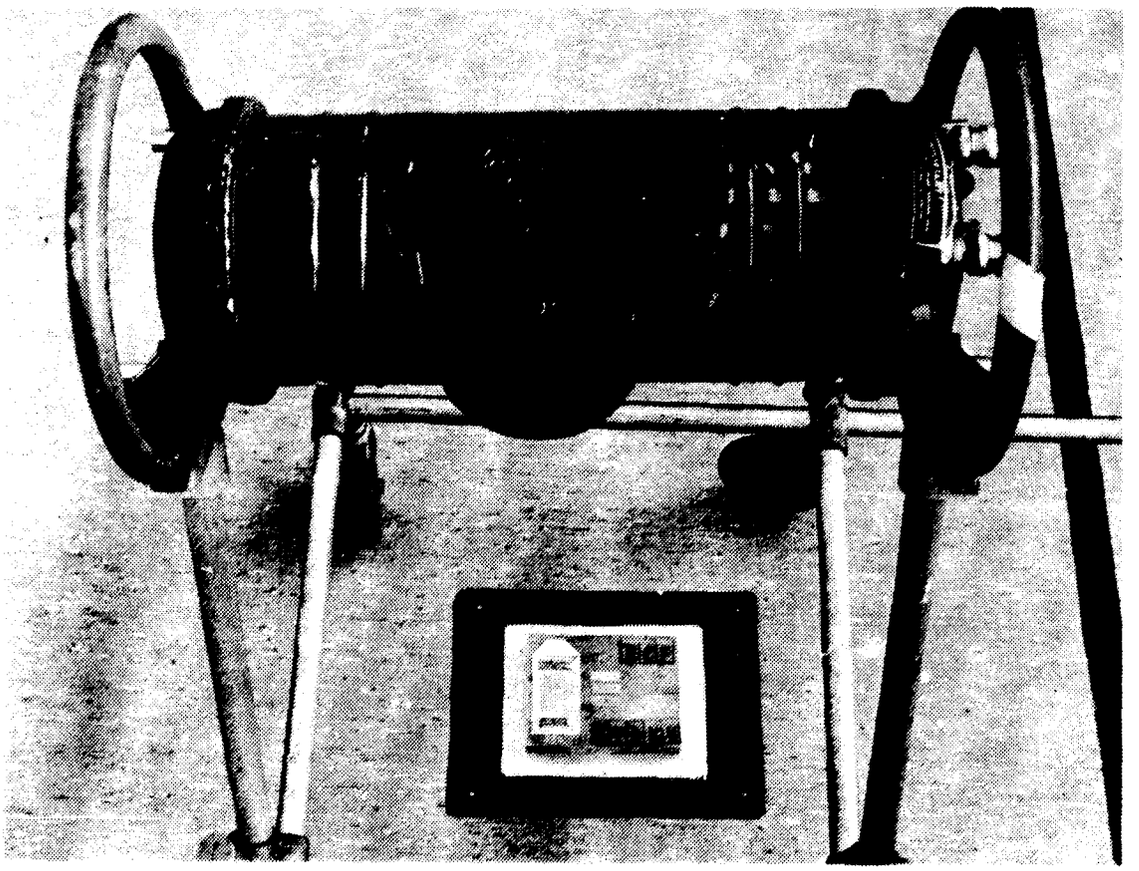


Fig.1. Andrex 180 kV X-ray machine (self-rectified, single-tank) used for radiography of the 30-mm Al plate

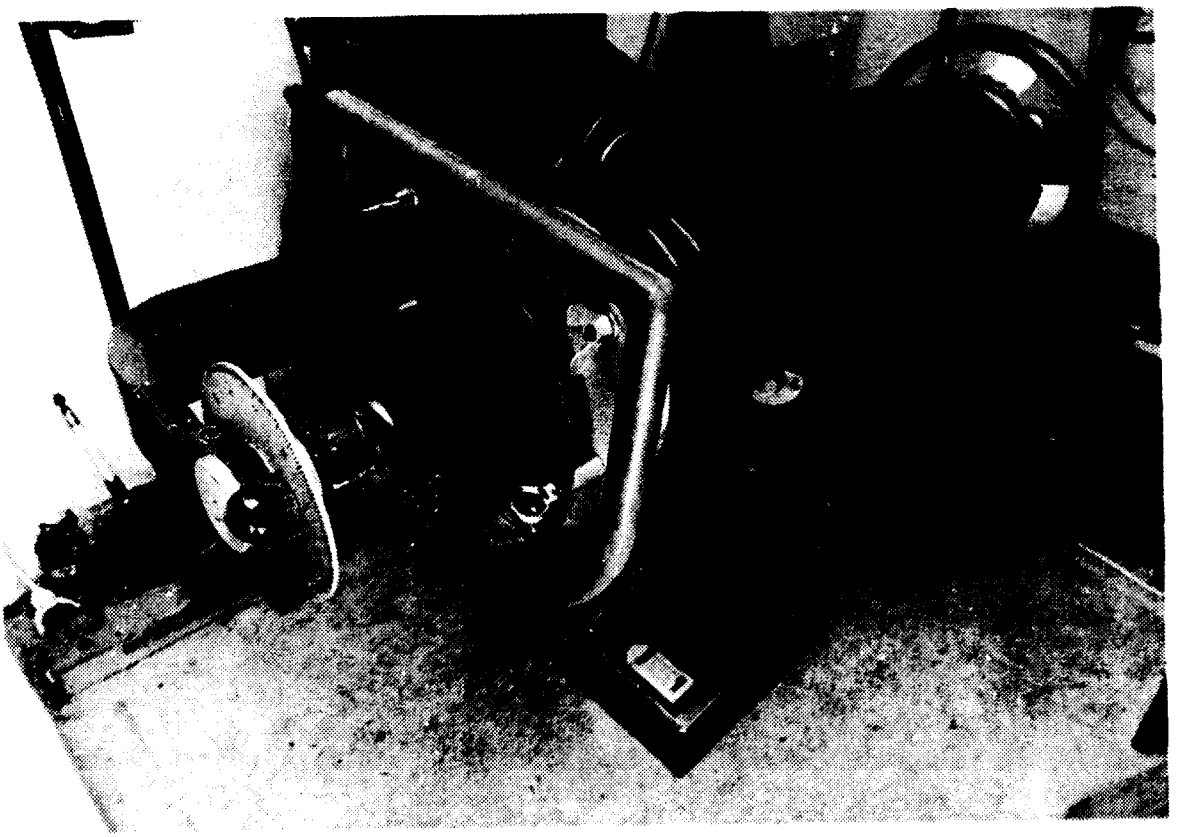


Fig.2. Andrex 300 kV X-ray machine (self-rectified, single-tank) used for radiography of 10-mm Fe plate

6. IMAGE QUALITY INDICATORS

Two types of image quality indicators were used: ISO wire IQI's and ASTM penetrameters. The relative merits and disadvantages of using those two systems were discussed in [8,9], whereas in [2] details about the IQI's are given.

In fig. 3 the ISO wire IQI's and ASTM penetrameters used for radiography of Al and Fe plates are shown. As a rule the 10 to 16 wire IQI's were used for all thicknesses of the plates under examination. For a 10-mm plate 0.1, 0.2 and 0.4-mm penetrameters were used, whereas for 30 mm - 0.3, 0.6 and 1.2-mm penetrameters were necessary.

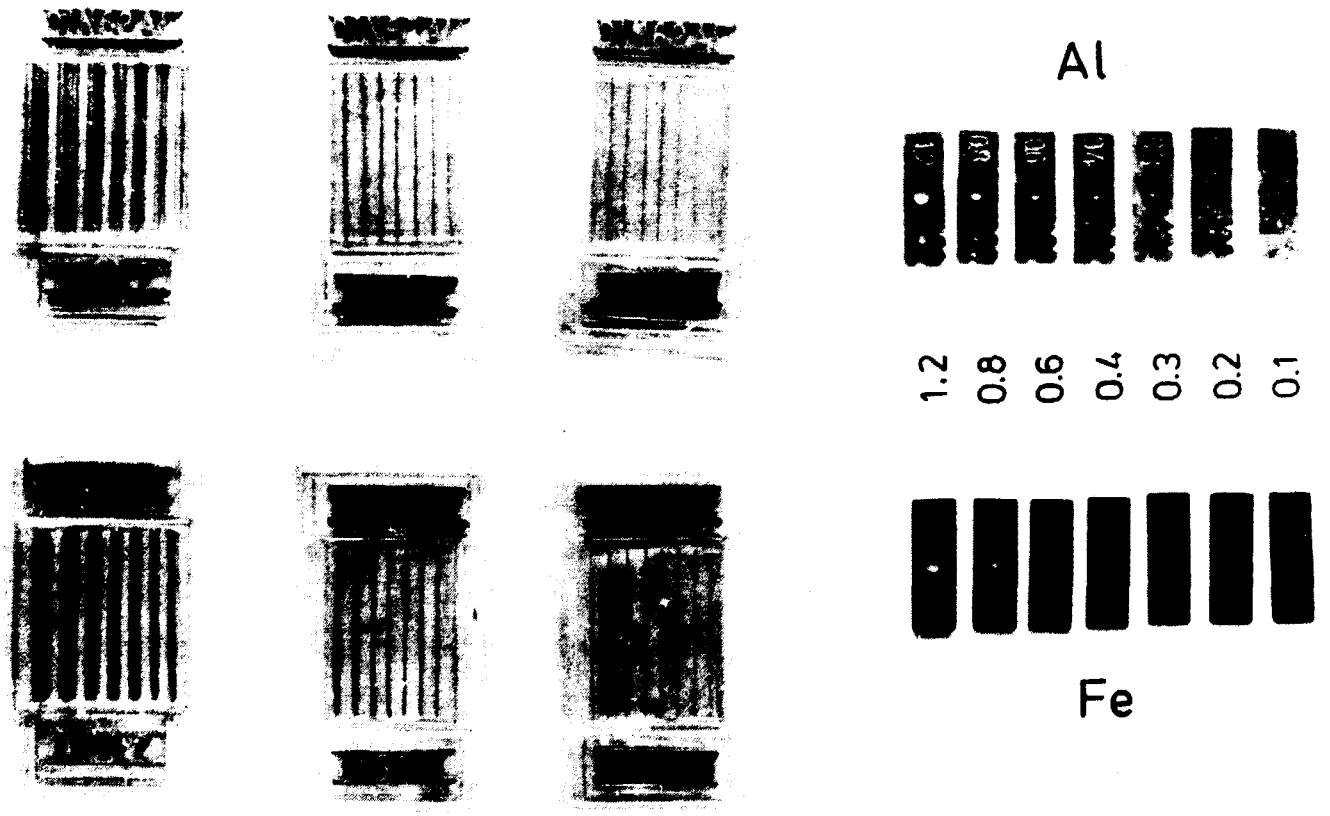


Fig.3. ISO wire IQI's and ASTM penetrameters for Al and Fe

7. OBJECTS EXAMINED

A 30-mm thick Al and a 10 mm Fe plate were used together with the IQI's described above. They were shown in figs. 1 and 2.

8. EXAMINATION PROCEDURE

The examination procedure by the constant exposure technique was as follows:

For the slowest X-ray film (Kodak Industrex SR and Agfa-Gevaert D2) kilovoltage giving a film density of $D_f = 2.5$ was chosen for an exposure of 25 mAmin for 30 mm Al and 100 mAmin for 10 mm Fe. Those respective kilovoltages were 170 (for Al) and 215 kV (for Fe).

Thereafter, each film and paper was exposed at those constant exposures (25 mAmin for Al and 100 mAmin for Fe) so as to reach a film $D_f = 2.5$ or paper $D_p = 1.0$ density by lowering the kilovoltage accordingly.

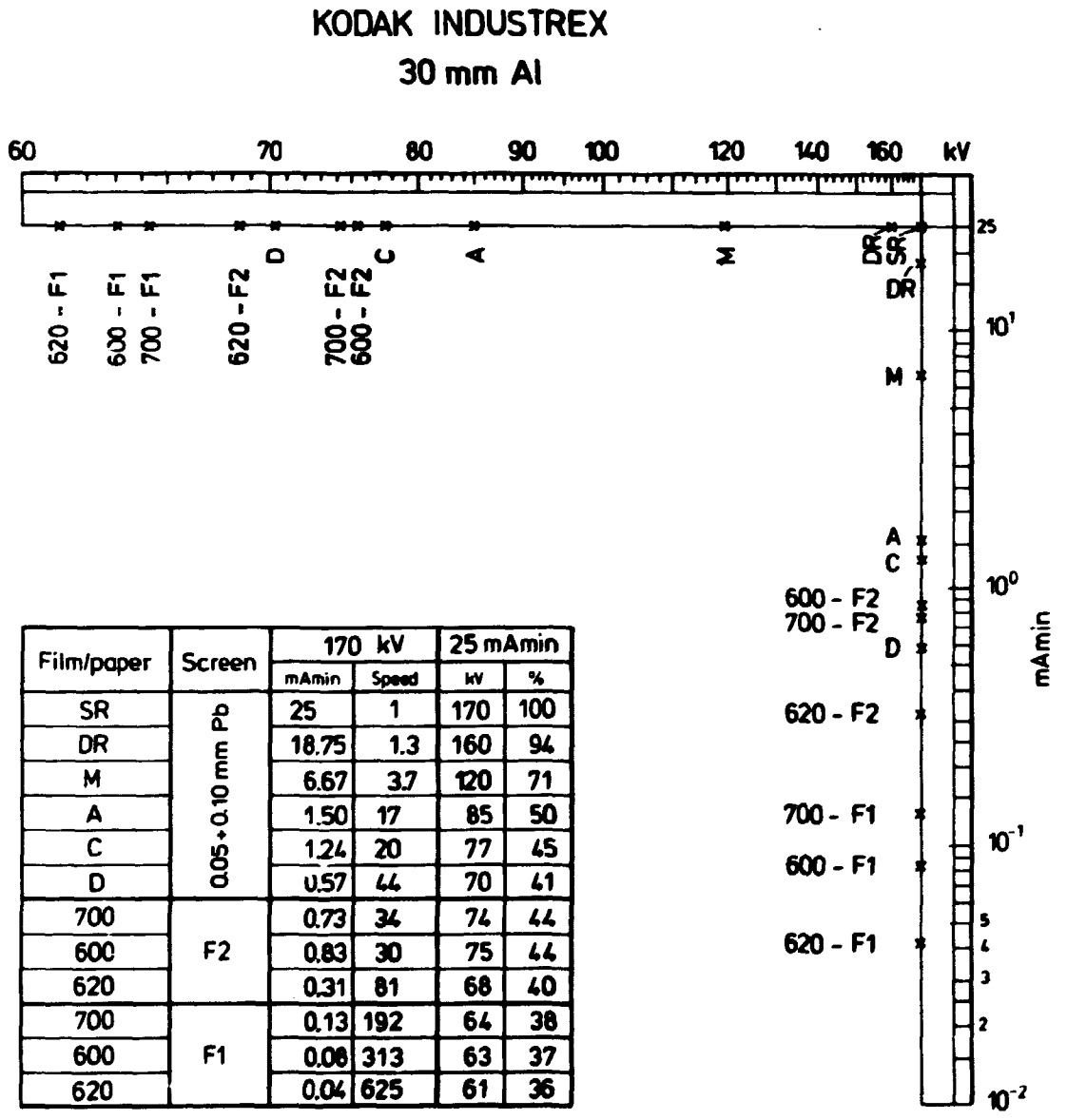
Thus a comparison is possible of the relative decrease of kilovoltage, which gives the same density (D_f or D_p), for the same exposure (mAmin).

To be able to calculate the relative speed of different film or paper systems a comparison was made at constant kilovoltages (170 kV for Al and 215 kV for Fe). There at chose kilovoltages exposures were made so as to reach densities of $D_f = 2.5$ or $D_p = 1.0$. By comparing different exposures (in mAmin) necessary to obtain those film/paper densities (at constant kilovoltages) relative speed can be directly determined.

9. RELATIVE SPEED AND KILOVOLTAGE

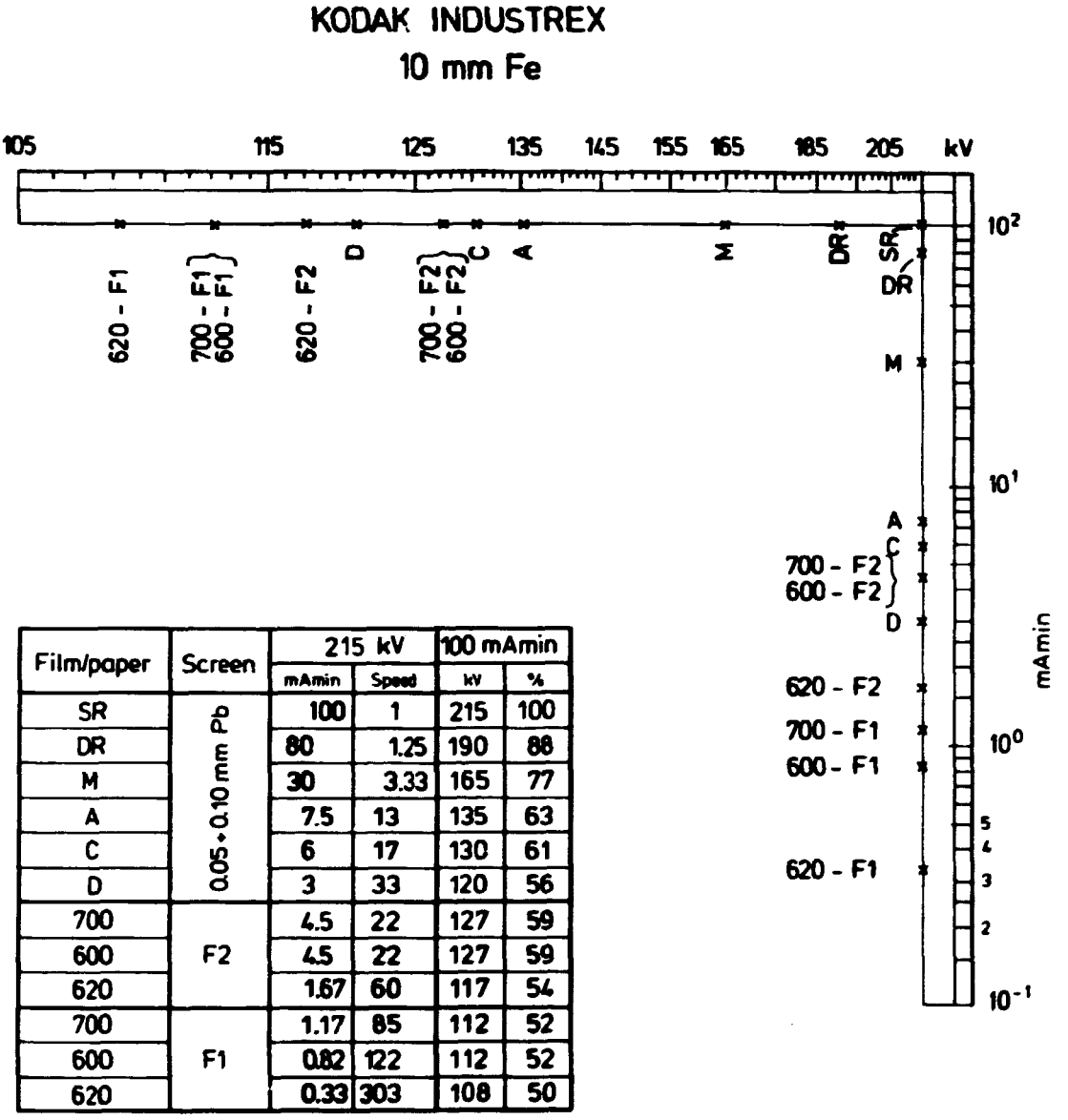
The results reached by using the examination procedure described above are presented in fig. 4 for Kodak Industrex

systems and 30 mm Al, whereas fig. 5 shows similar results for 10 mm Pe.



Film/paper	Screen	170 kV		25 mAmin	
		mAmin	Speed	kV	%
SR	0.05+0.10 mm Pb	25	1	170	100
DR		18.75	1.3	160	94
M		6.67	3.7	120	71
A		1.50	17	85	50
C		1.24	20	77	45
D		0.57	44	70	41
700	F2	0.73	34	74	44
600		0.83	30	75	44
620		0.31	81	68	40
700	F1	0.13	192	64	38
600		0.08	313	63	37
620		0.04	625	61	36

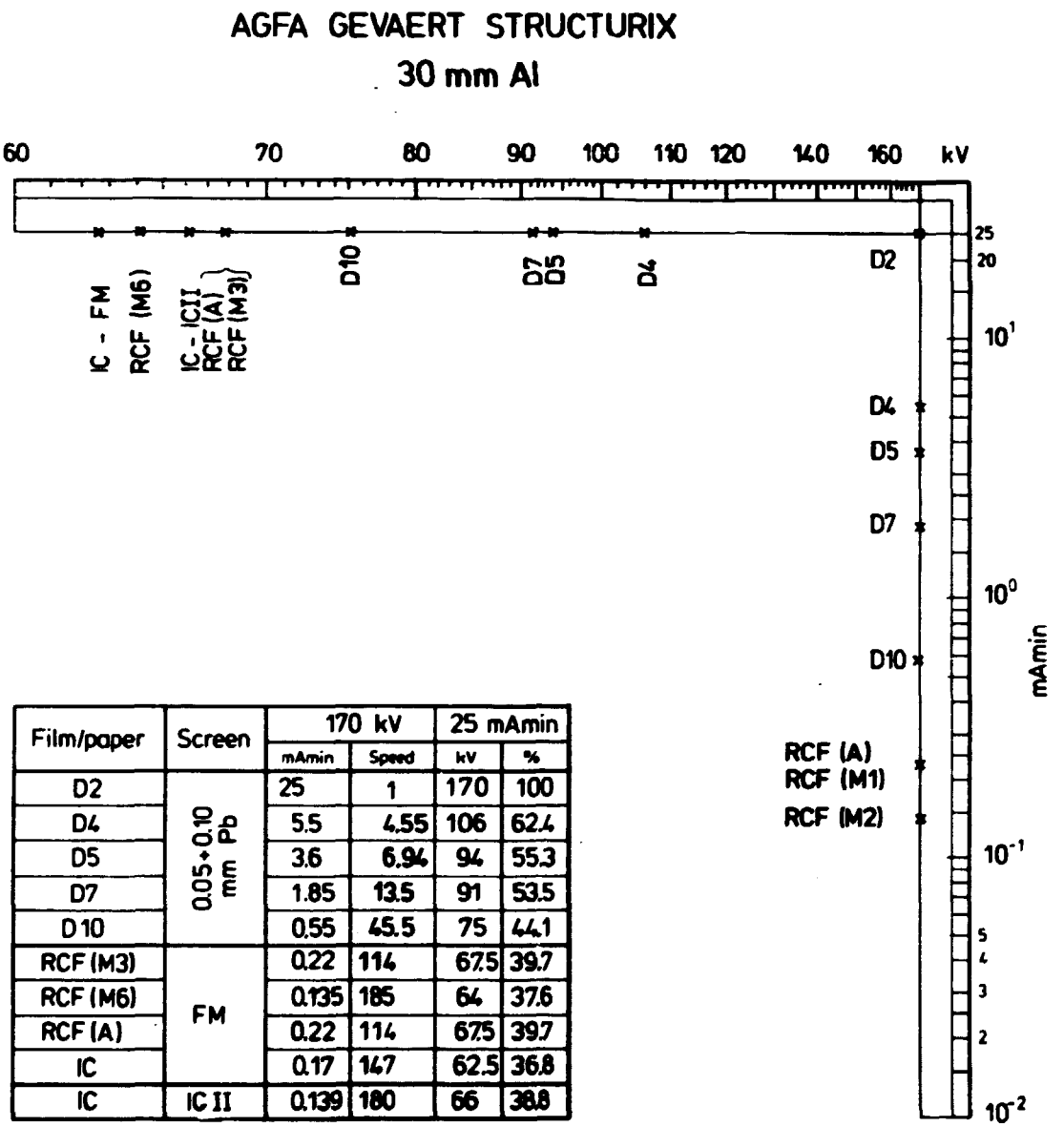
Fig.4. Comparison of relative speed and kilovoltage for Kodak Industrex systems at 30 mm Al



Film/paper	Screen	215 kV		100 mAmin	
		mAmin	Speed	kV	%
SR	0.05+0.10 mm Pb	100	1	215	100
DR		80	1.25	190	88
M		30	3.33	165	77
A		7.5	13	135	63
C		6	17	130	61
D		3	33	120	56
700	F2	4.5	22	127	59
600		4.5	22	127	59
620		1.67	60	117	54
700	F1	1.17	85	112	52
600		0.82	122	112	52
620		0.33	303	108	50

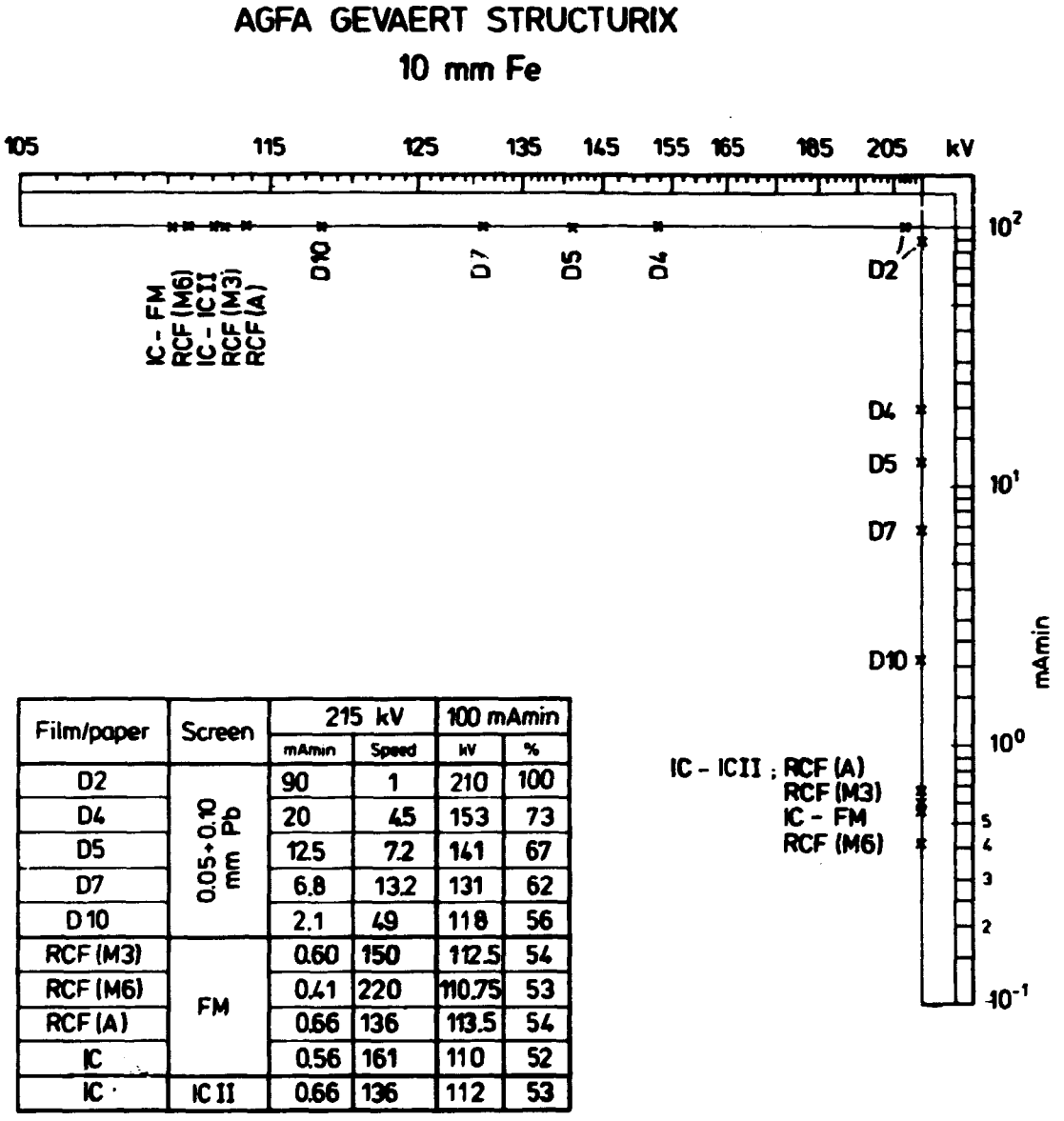
Fig.5. Comparison of relative speed and kilovoltage between Kodak Industrex systems at 10 mm Fe

A similar comparison performed for Agfa-Gevaert Structurix systems is shown in fig. 6 for 30 mm Al and on fig. 7 for 10 mm Fe.



Film/paper	Screen	170 kV		25 mAmin	
		mAmin	Speed	kV	%
D2	0.05+0.10 mm Pb	25	1	170	100
D4		5.5	4.55	106	62.4
D5		3.6	6.94	94	55.3
D7		1.85	13.5	91	53.5
D10		0.55	45.5	75	44.1
RCF (M3)	FM	0.22	114	67.5	39.7
RCF (M6)		0.135	185	64	37.6
RCF (A)		0.22	114	67.5	39.7
IC		0.17	147	62.5	36.8
IC	IC II	0.139	180	66	38.8

Fig.6. Comparison of relative speed and kilovoltage between Agfa-Gevaert Structurix systems at 30 mm Al



Film/paper	Screen	215 kV		100 mAmin	
		mAmin	Speed	kV	%
D2	0.05+0.10 mm Pb	90	1	210	100
D4		20	45	153	73
D5		12.5	7.2	141	67
D7		6.8	13.2	131	62
D10		2.1	49	118	56
RCF (M3)	FM	0.60	150	112.5	54
RCF (M6)		0.41	220	110.75	53
RCF (A)		0.66	136	113.5	54
IC		0.56	161	110	52
IC	IC II	0.66	136	112	53

Fig.7. Comparison of relative speed and kilovoltage between Agfa-Gevaert Structurix systems at 10 mm Fe

The RCF film was processed manually (M) at different developing temperatures and times and automatically (A). Different developer concentrations were thereby used. Those processing modes are shown in fig. 8.

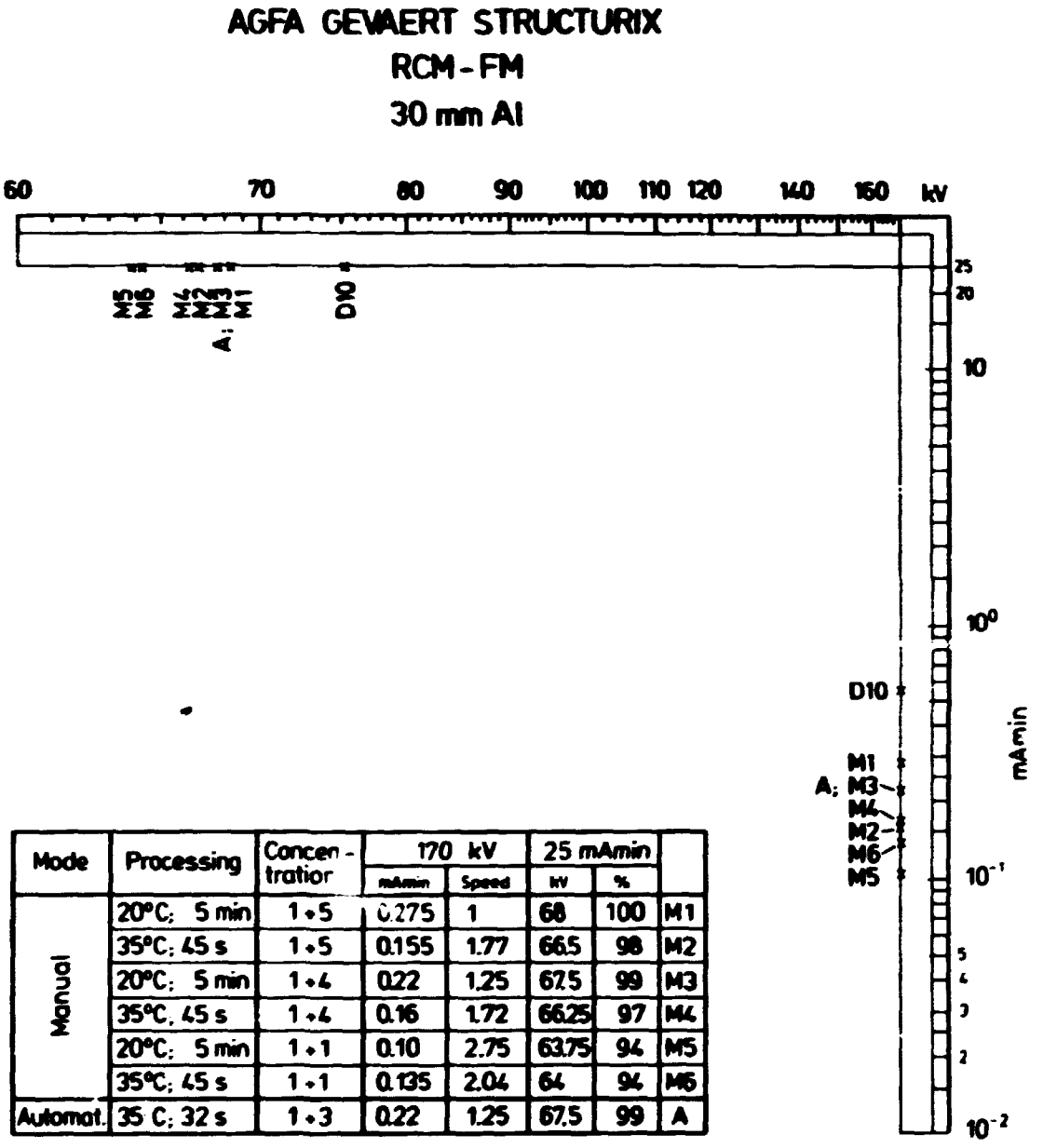
Mode	Processing	Concen-tration	
Manual	20°C; 5 min	1+5	M1
	35°C; 45 s	1+5	M2
	20°C; 5 min	1+4	M3
	35°C; 45 s	1+4	M4
	20°C; 5 min	1+1	M5
	35°C; 45 s	1+1	M6
Automat.	35°C; 32 s	1+3	A

Fig.8. Processing modes for Agfa-Gevaert Structurix RCF film

10. PROCESSING

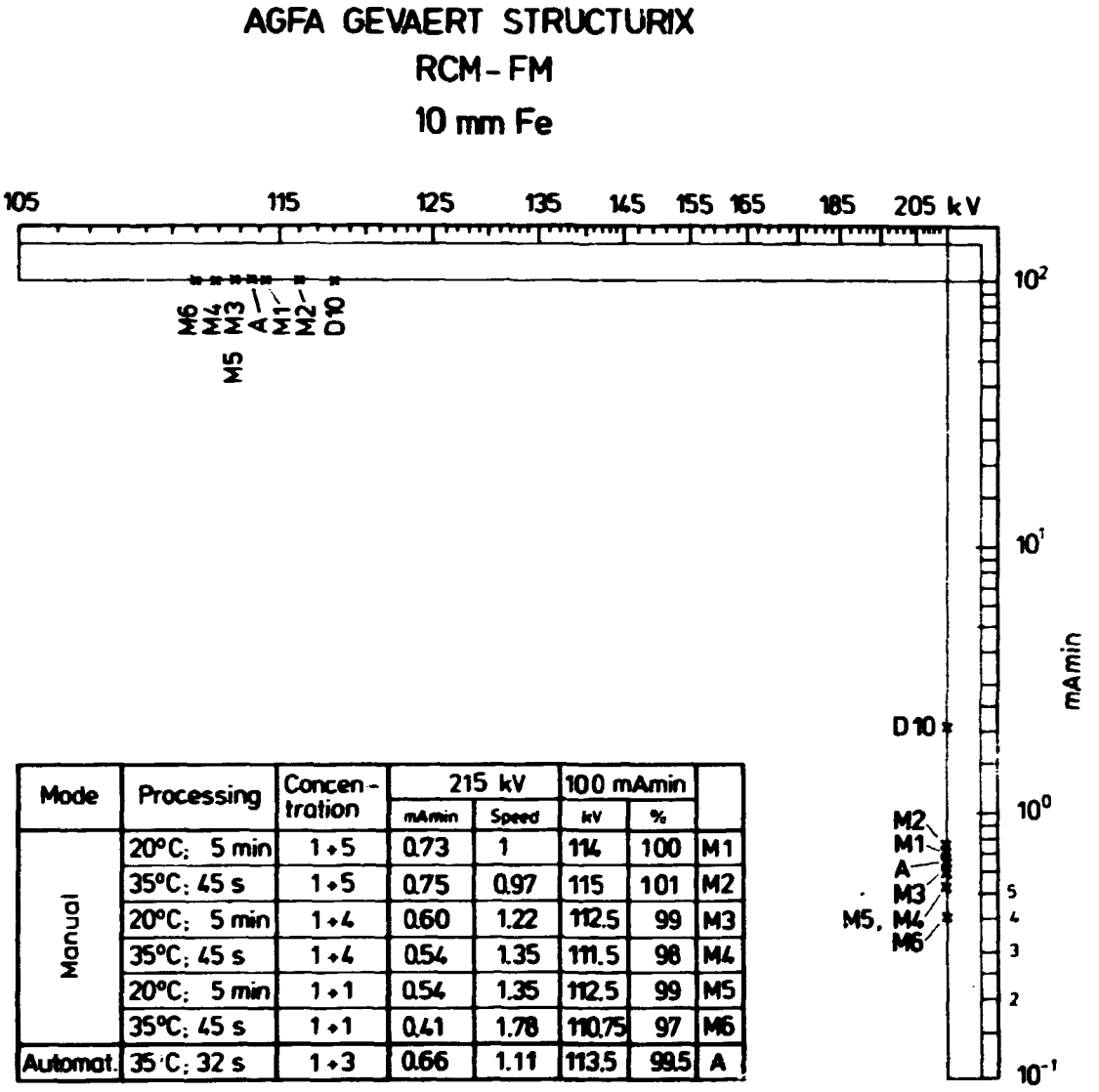
As mentioned above, all conventional X-ray films were manually processed and the radiographic papers were processed in automatic processors according to procedures recommended by their manufacturers.

Different processing modes were tried for the Agfa-Gevaert Structurix RCF film used with FM screens. Both manual as well as automatic processing was tested, using different developing temperatures, time and developer concentration. The influence of the processing mode on the relative speed and kilovoltage is shown in figs. 9 and 10.



Mode	Processing	Concentration	170 kV		25 mAmin		
			mAmin	Speed	kV	%	
Manual	20°C; 5 min	1+5	0.275	1	68	100	M1
	35°C; 45 s	1+5	0.155	1.77	66.5	98	M2
	20°C; 5 min	1+4	0.22	1.25	67.5	99	M3
	35°C; 45 s	1+4	0.16	1.72	66.25	97	M4
	20°C; 5 min	1+1	0.10	2.75	63.75	94	M5
	35°C; 45 s	1+1	0.135	2.04	64	94	M6
Automat.	35 C; 32 s	1+3	0.22	1.25	67.5	99	A

Fig.9. Comparison of relative speed and kilovoltage between Agfa-Gevaert Structurix RCF film with FM screens at 30 mm Al



Mode	Processing	Concentration	215 kV		100 mAmin		
			mAmin	Speed	kV	%	
Manual	20°C; 5 min	1+5	0.73	1	114	100	M1
	35°C; 45 s	1+5	0.75	0.97	115	101	M2
	20°C; 5 min	1+4	0.60	1.22	112.5	99	M3
	35°C; 45 s	1+4	0.54	1.35	111.5	98	M4
	20°C; 5 min	1+1	0.54	1.35	112.5	99	M5
	35°C; 45 s	1+1	0.41	1.78	110.75	97	M6
Automat.	35°C; 32 s	1+3	0.66	1.11	113.5	99.5	A

Fig.10. Comparison of relative speed and kilovoltage for Agfa-Gevaert Structurix RCP film with FM screens at 10 mm Fe

As explained in 3 above for manual processing, modes M3 and M6 are recommended by the film manufacturer. Although, the M6 mode, requiring a high concentration of the developer (1 + 1) and a relatively high temperature (35°C), gives a higher relative speed and permits the use of lower kilovoltage, is not practical and can hardly be recommended unless higher speed is of primary importance.

As can be seen (see figs. 9 & 10) there is practically no difference in relative speed or kilovoltage when using either the manual M3 or automatic A processing mode, whereas the use of the manual M6 mode can increase the speed by about 50%.

11. RADIOGRAPHIC IMAGE QUALITY

To be able to judge to what extent the fast radiographic systems can be used, the radiographic image quality obtained with those systems was tested. For that purpose the eqipment described above, indicators and test objects were used.

Each radiograph of an Al or Fe plate containing the images of the wire IQI's and ASTM penetrameters was visually examined by three persons and the results of their assessment were presented in the previously adapted form of diagrams [2,3,5,8,9], on which the finding of each observer is marked by a black line, whereas the dotted strip signifies that all three persons were of the same opinion. The results obtained before were supplemented with those obtained during the present investigation using Agfa-Gevaert D 10 and RCF films and IC paper with fluorometallic screens.

11.1. Kodak systems

The results of the investigation performed with Kodak films and papers were already presented before in [2]. The percent radiographic quality is presented in figs. 11 and 12 for 30 mm Al and in figs. 13 and 14 for 10 mm Fe.

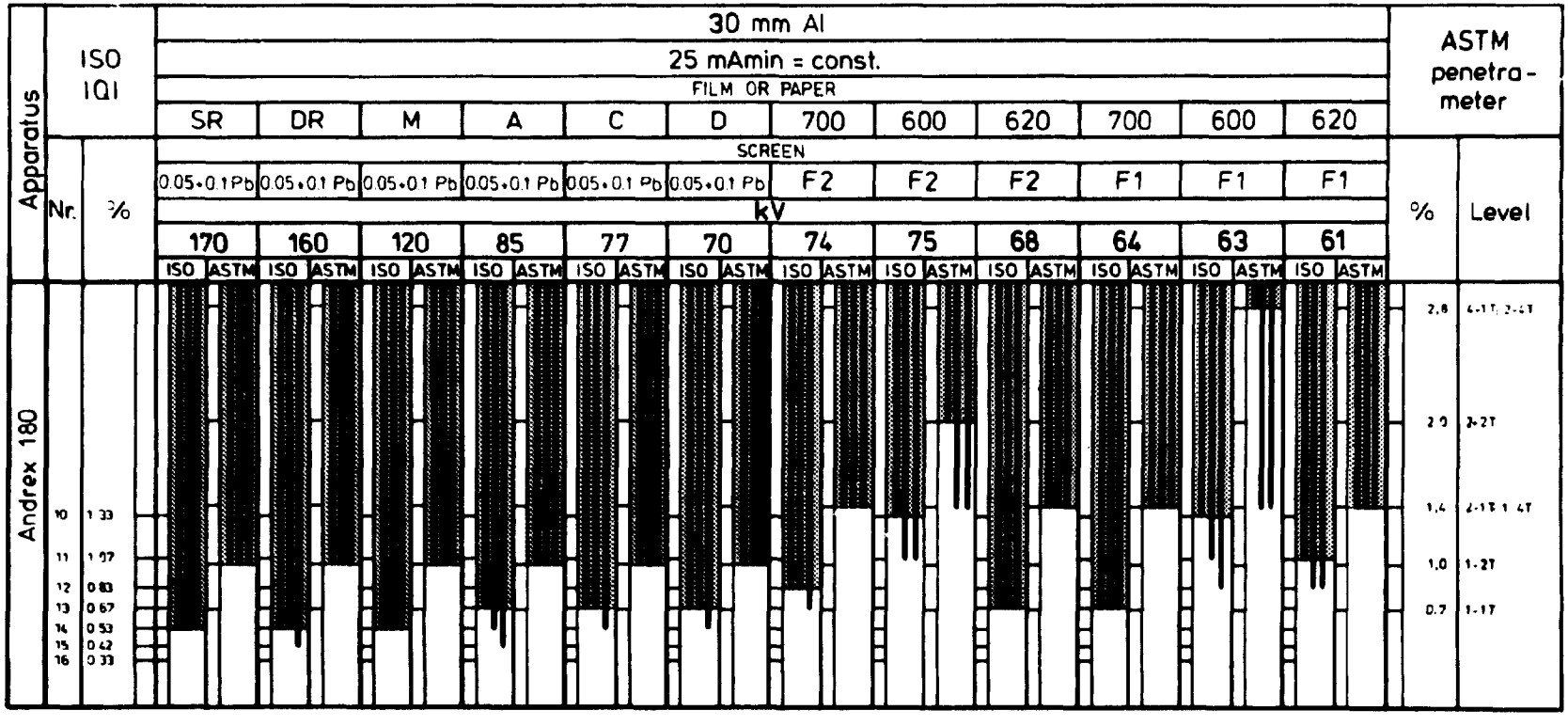


Fig.11. Percent radiographic quality for Kodak films and papers for 30 mm Al at 25 mAmin

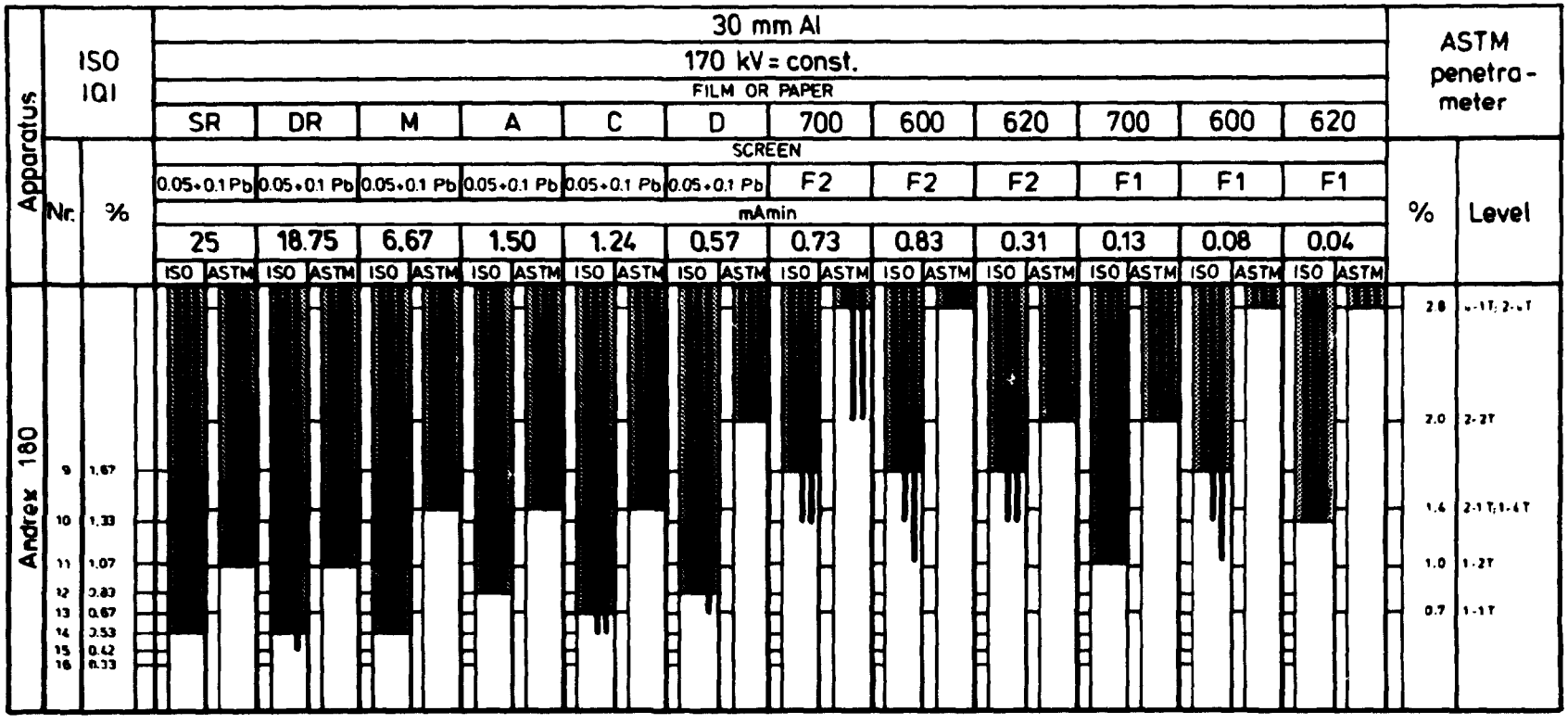


Fig.12. Percent radiographic quality for Kodak films and papers for 30 mm Al at 170 kV

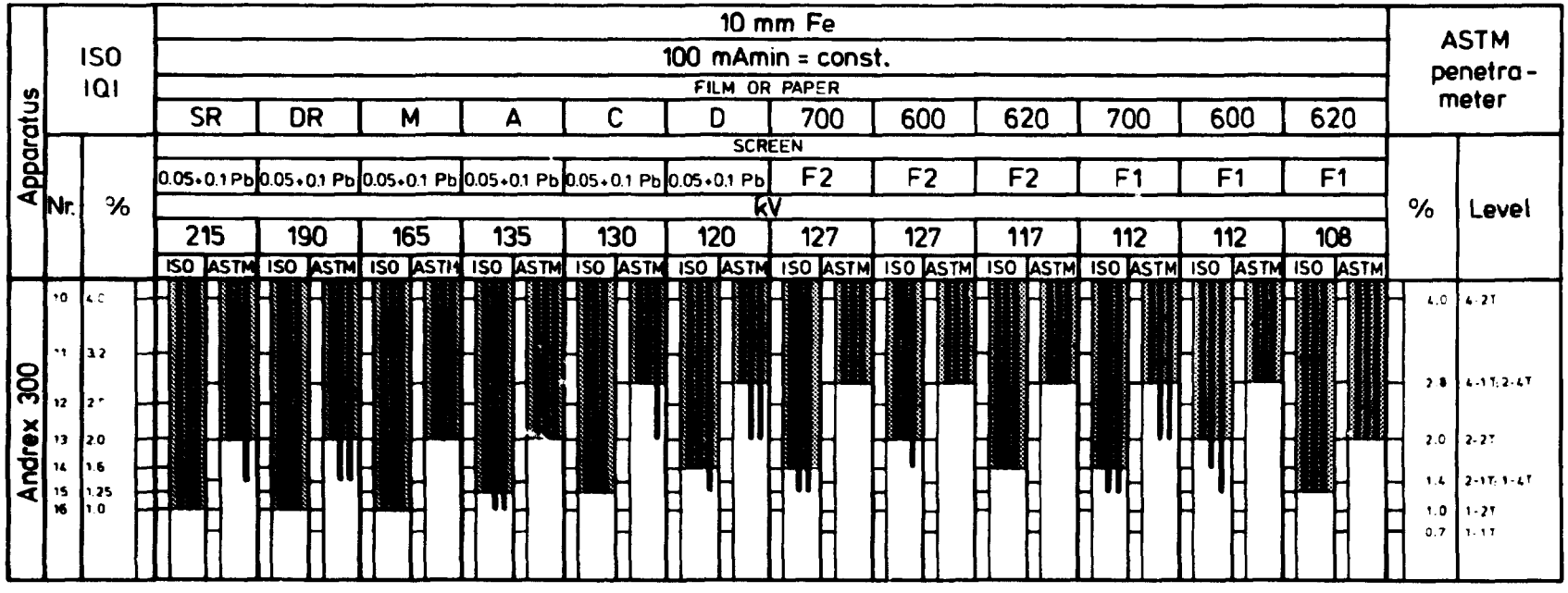


Fig.13. Percent radiographic quality for Kodak films and papers for 10 mm Fe at 100 mAmin

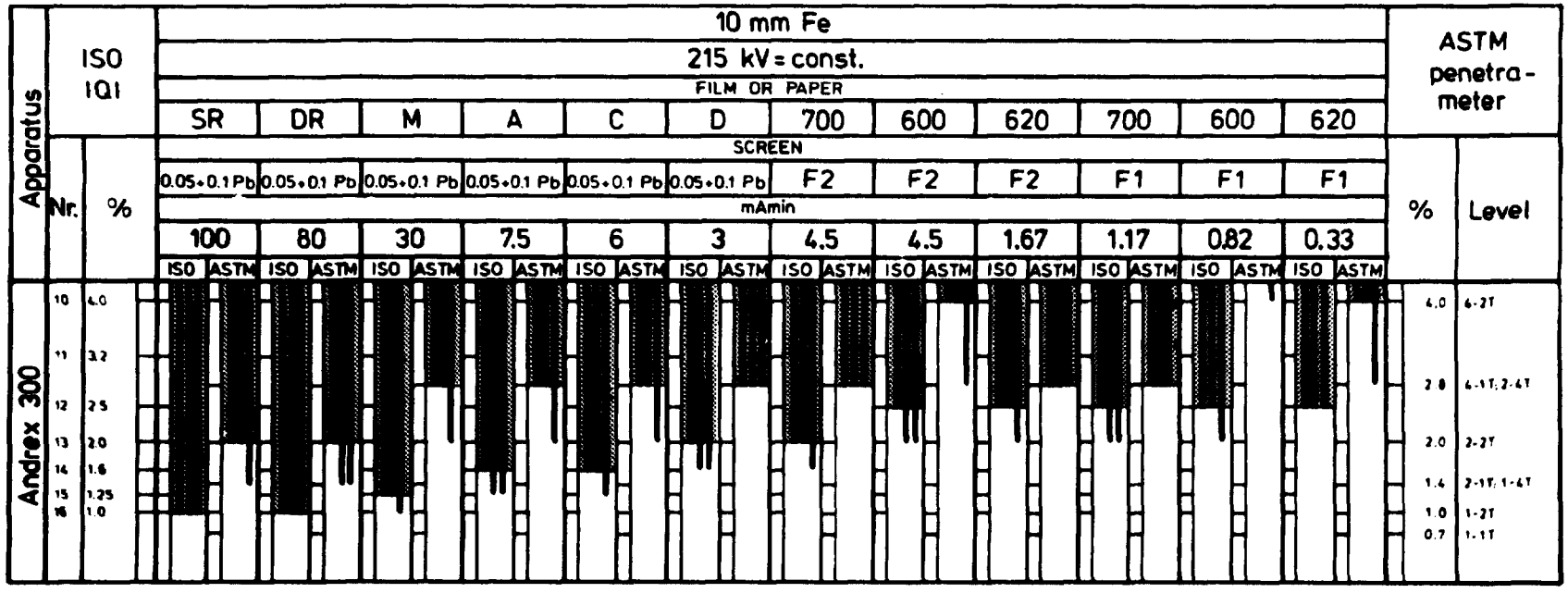


Fig.14. Percent radiographic quality for Kodak films and papers for 10 mm Fe and 215 kV

11.2. Agfa-Gevaert systems

In the previous investigation [2] only the Agfa-Gevaert Structurix IC paper with IC II and FM screens were tested. Now those tests were supplemented with the use of other brands of the Structurix film. The RCF film was also investigated using different processing modes.

The percent radiographic quality for all those systems is presented in figs. 15 and 16 for 30 mm Al and figs. 17 and 18 for 10 mm Fe.

As mentioned in 3 and 10 above, the RCF film manufacturer recommends normal processing for this film brand in (1 + 4) concentrated developer at 20°C for 2 min (M3) or in (1 + 1) developer at 35°C for 45 s (M6). An automatic processing in (1 + 3) developer at 32 s is also recommended (A).

A comparison containing only those processing modes for the RCF film is shown in figs. 19 and 20 for 30 mm Al and figs. 21 and 22 for 10 mm Fe.

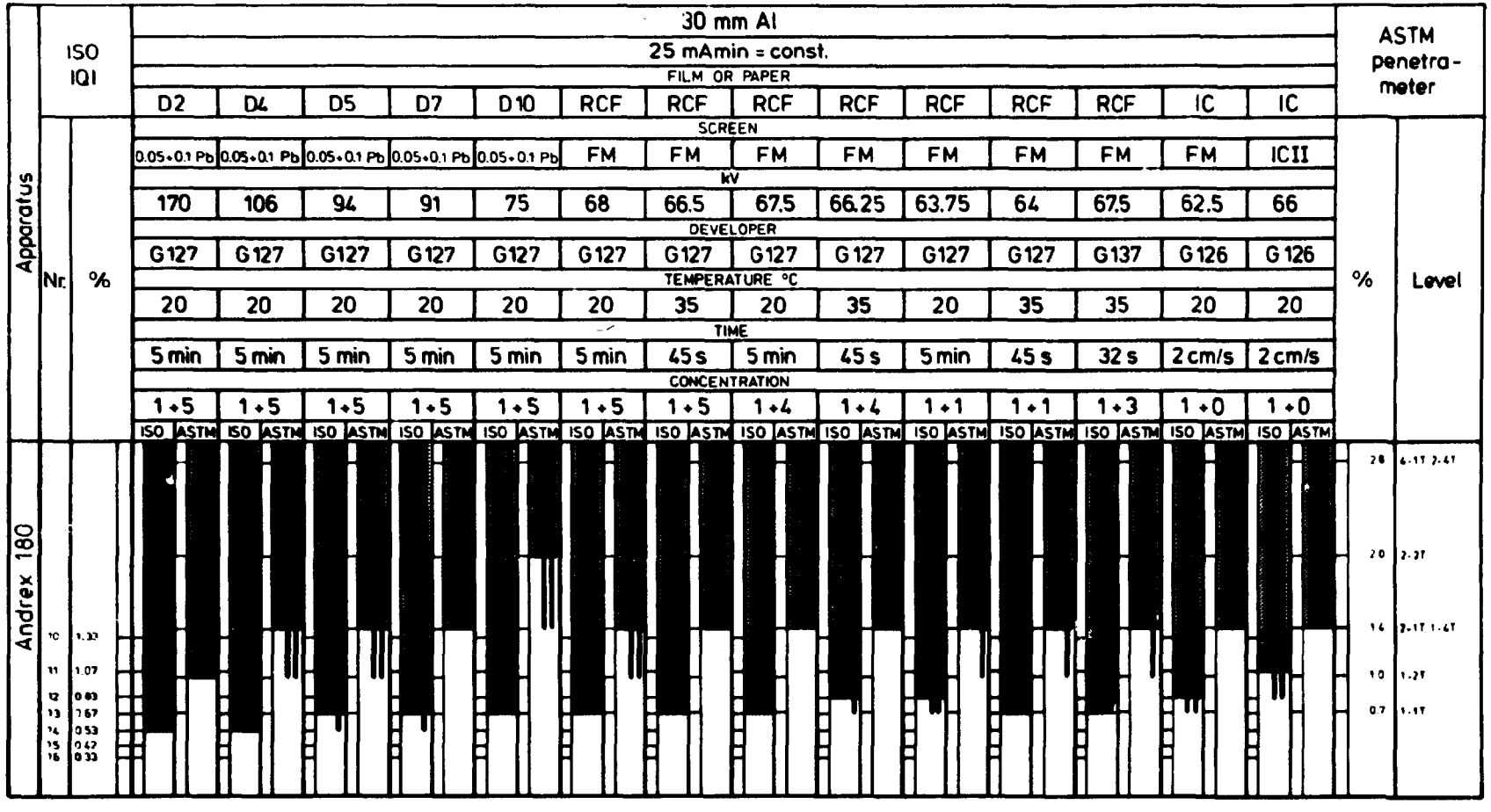


Fig.15. Percent radiographic quality for Agfa-Gevaert films and paper for 30 mm Al at 25 mAmin

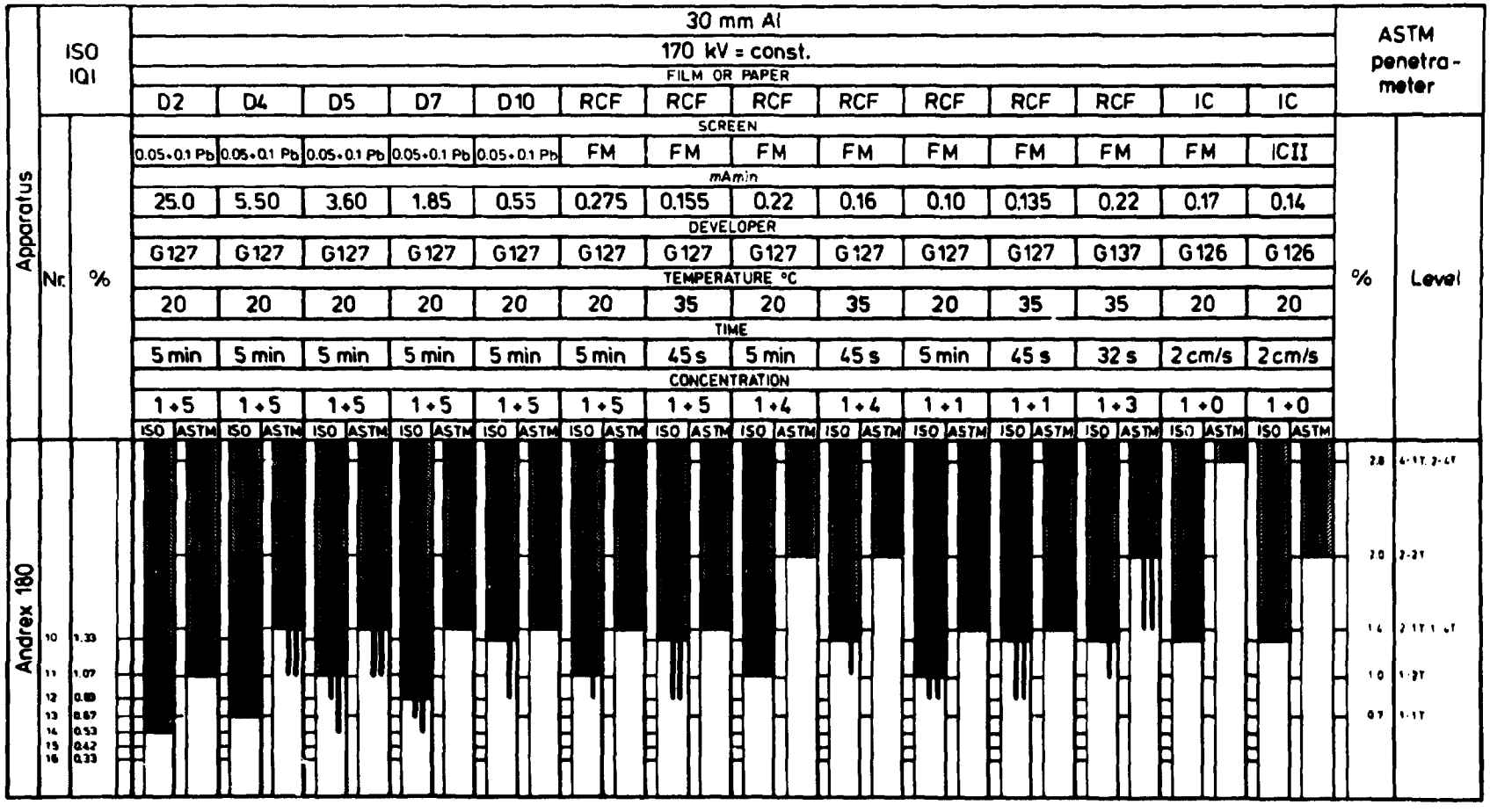


Fig.16. Percent radiographic quality for Agfa-Gevaert films and paper for 30 mm Al at 170 kV

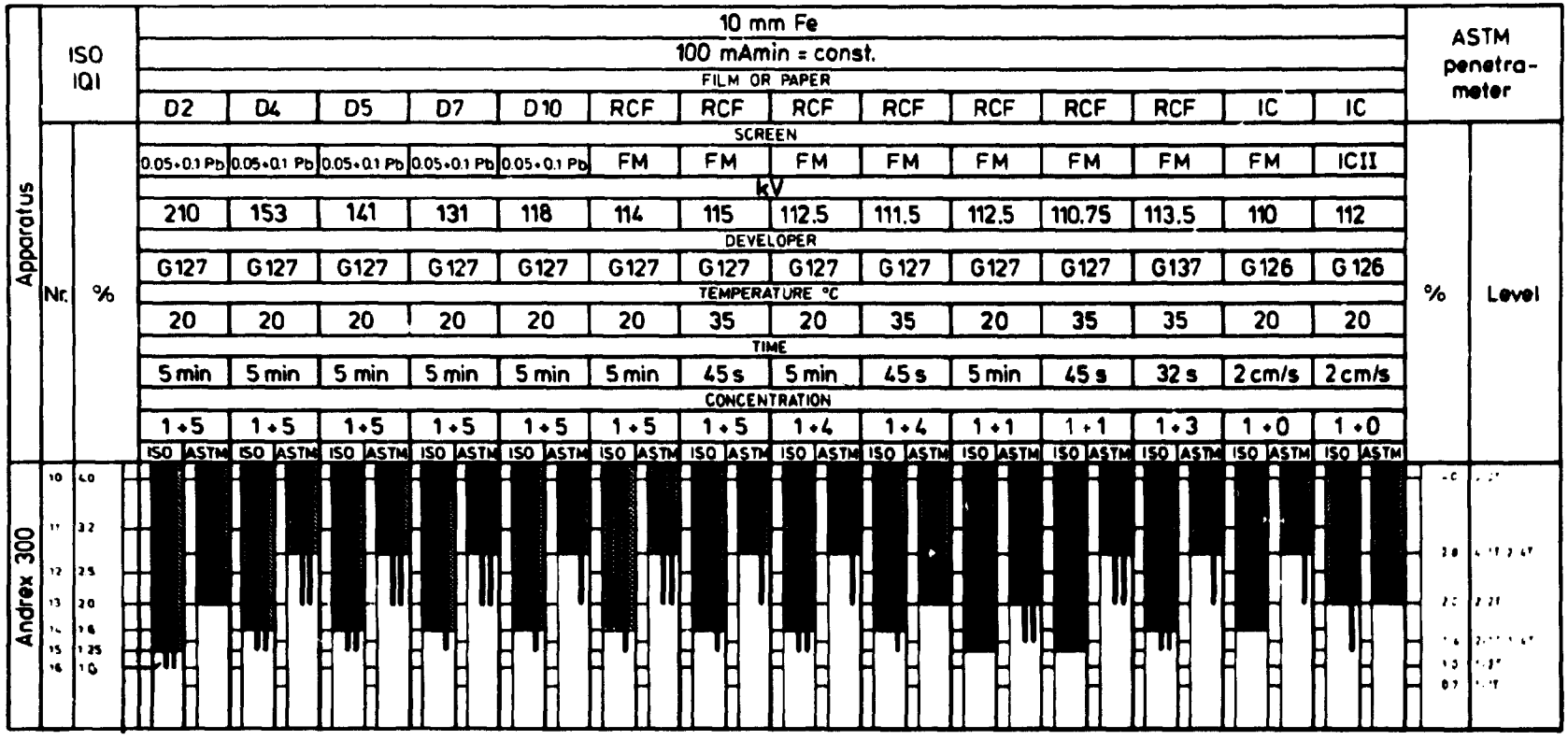


Fig.17. Percent radiographic quality for Agfa-Gevaert films and paper for 10 mm Fe at 100 mAmin

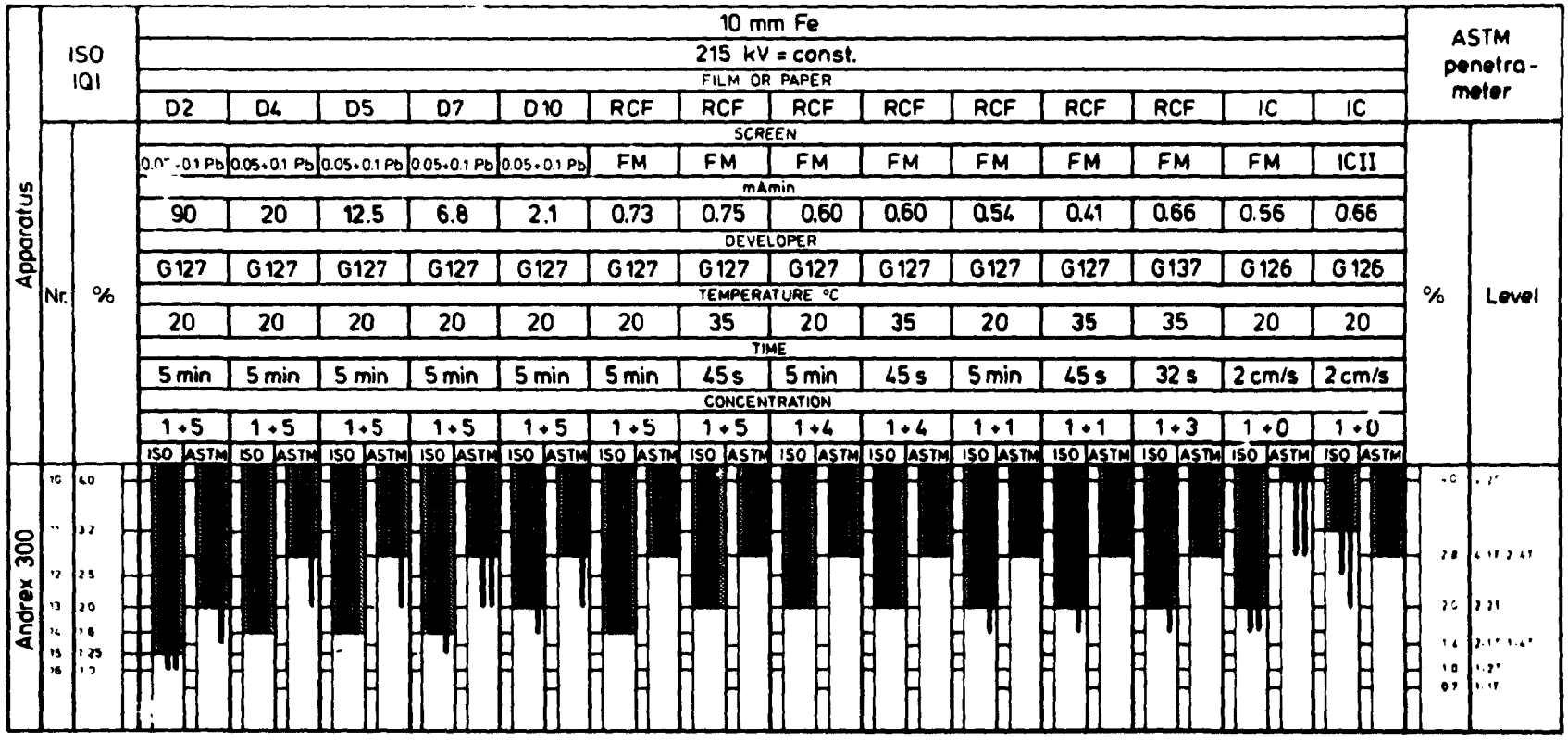


Fig.18. Percent radiographic quality for Agfa-Gevaert films and paper for 10 mm Fe at 215 kV.

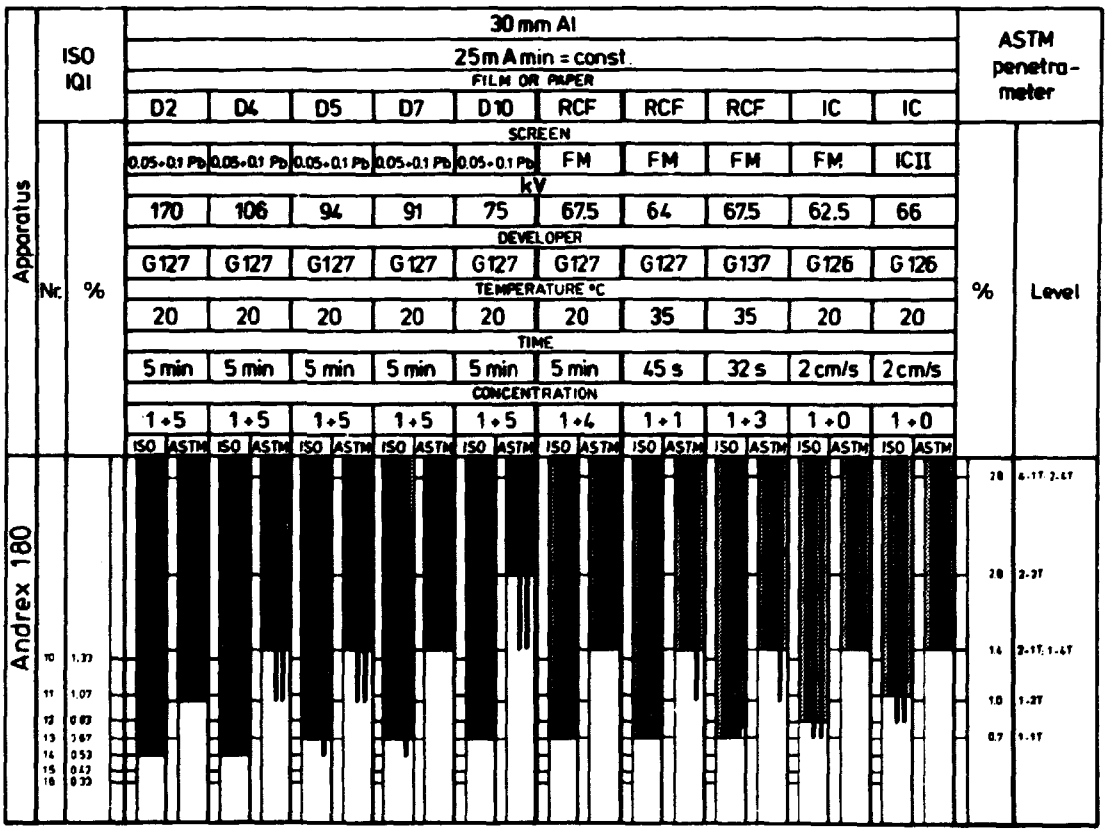


Fig.19. Percent radiographic quality for Agfa-Gevaert films and paper for 30 mm Al at 25 mAmin (for RCF recommended processing)

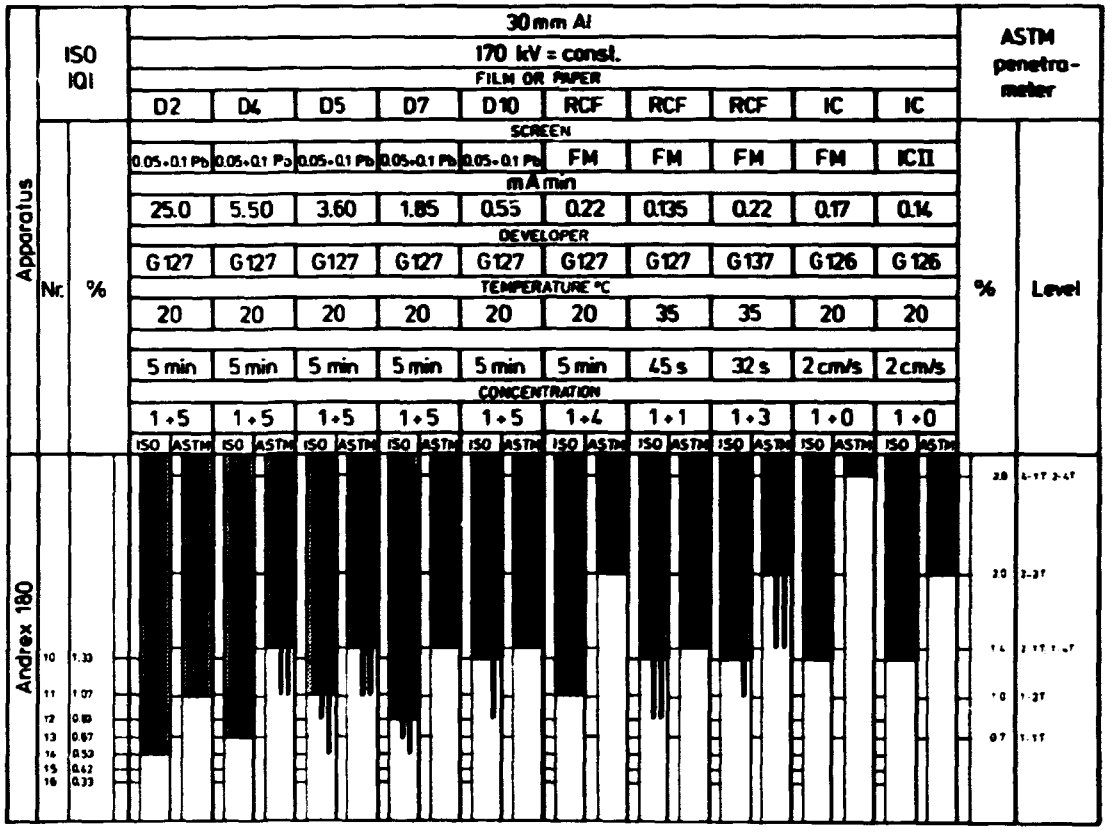


Fig.20. Percent radiographic quality for Agfa-Gevaert films and paper for 30 mm Al at 170 kV (for RCF recommended processing)

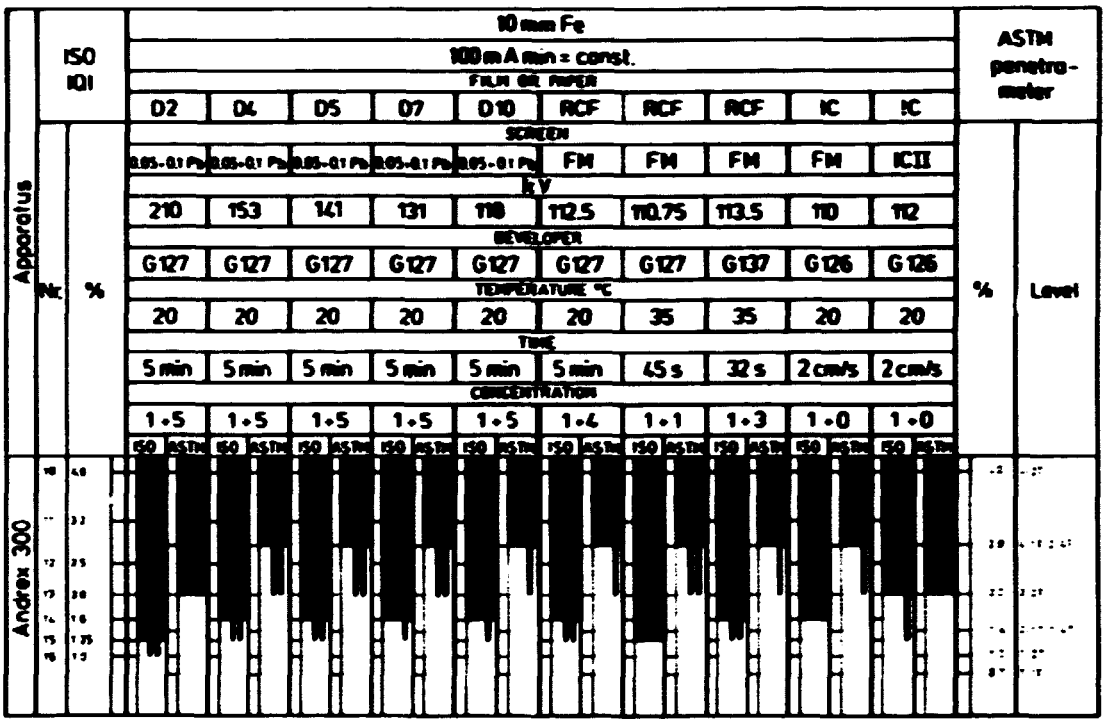


Fig.21. Percent radiographic quality for Agfa-Gevaert films and paper for 10 mm Fe at 100 mAmin (for RCF recommended processing)

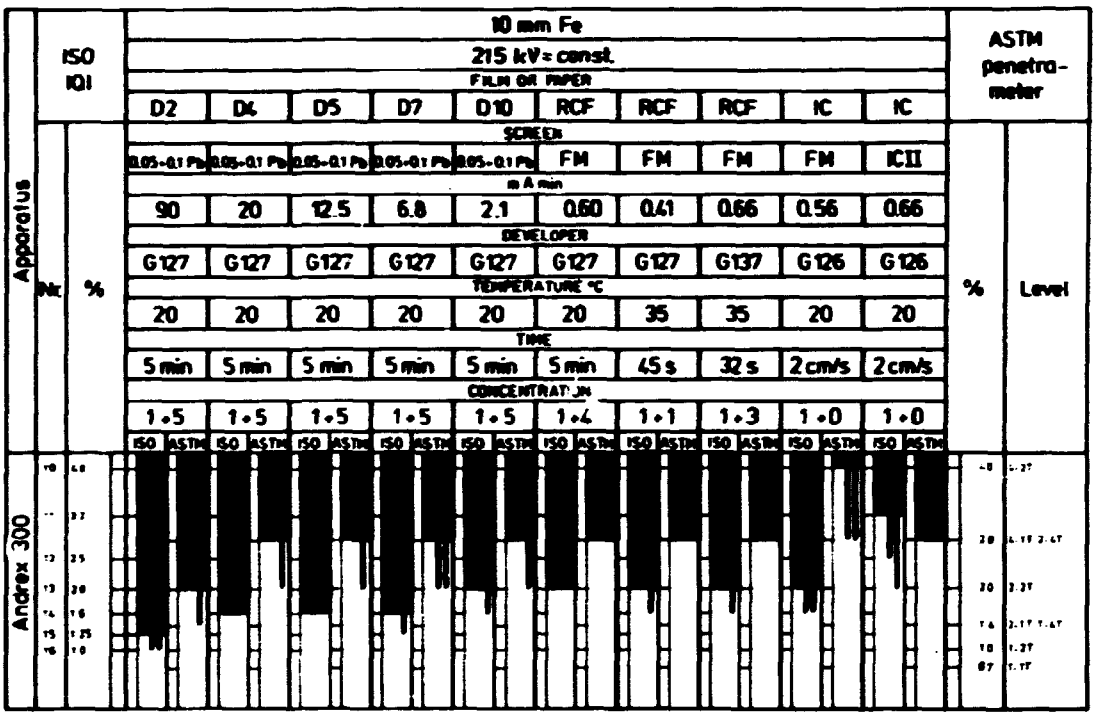


Fig.22. Percent radiographic quality for Agfa-Gevaert films and paper for 10 mm Fe at 215 kV (for RCF recommended processing)

11.3. Agfa-Gevaert fast systems

The comparison between only the fast systems (D 10 and RCF films and IC paper) is made in figs. 23 and 24 for 30 mm Al and figs. 25 and 26 for 10 mm Fe.

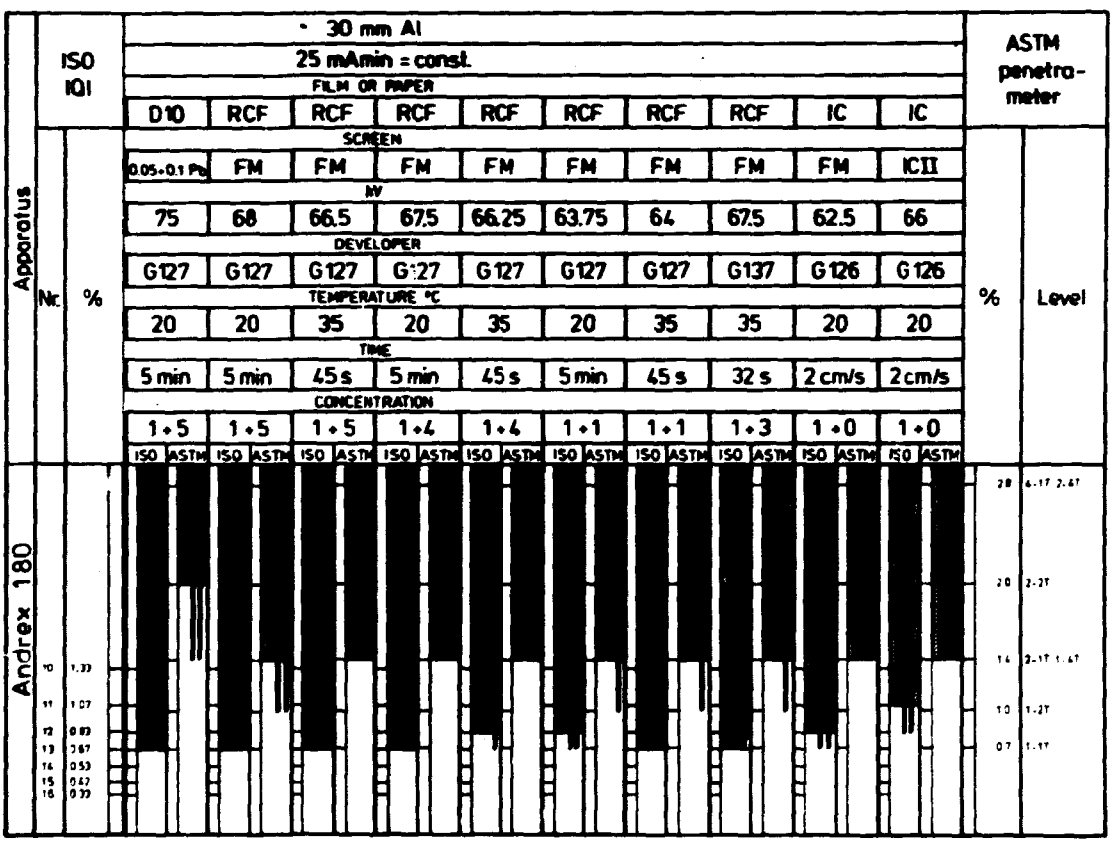


Fig.23. Percent radiographic quality for Agfa-Gevaert fast systems for 30 mm Al at 25 mAmin

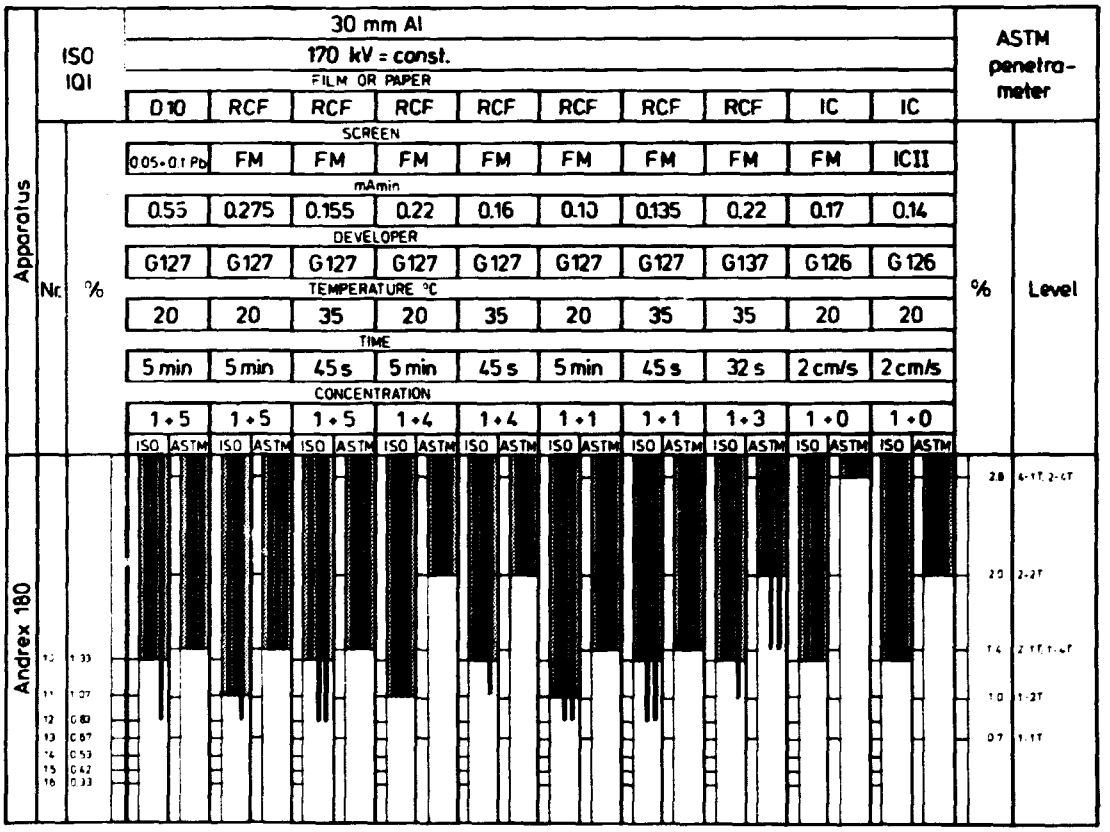


Fig.24. Percent radiographic quality for Agfa-Gevaert fast systems for 30 mm Al at 170 kV

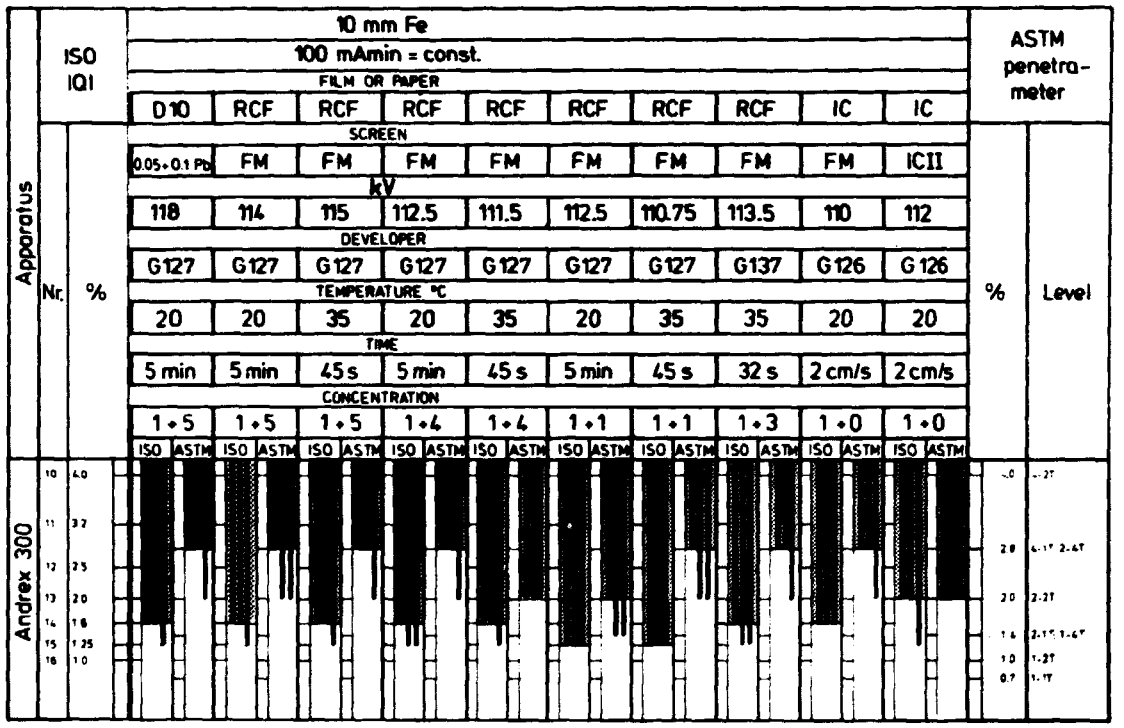


Fig.25. Percent radiographic quality for Agfa-Gevaert fast systems for 10 mm Fe at 100 mAmin

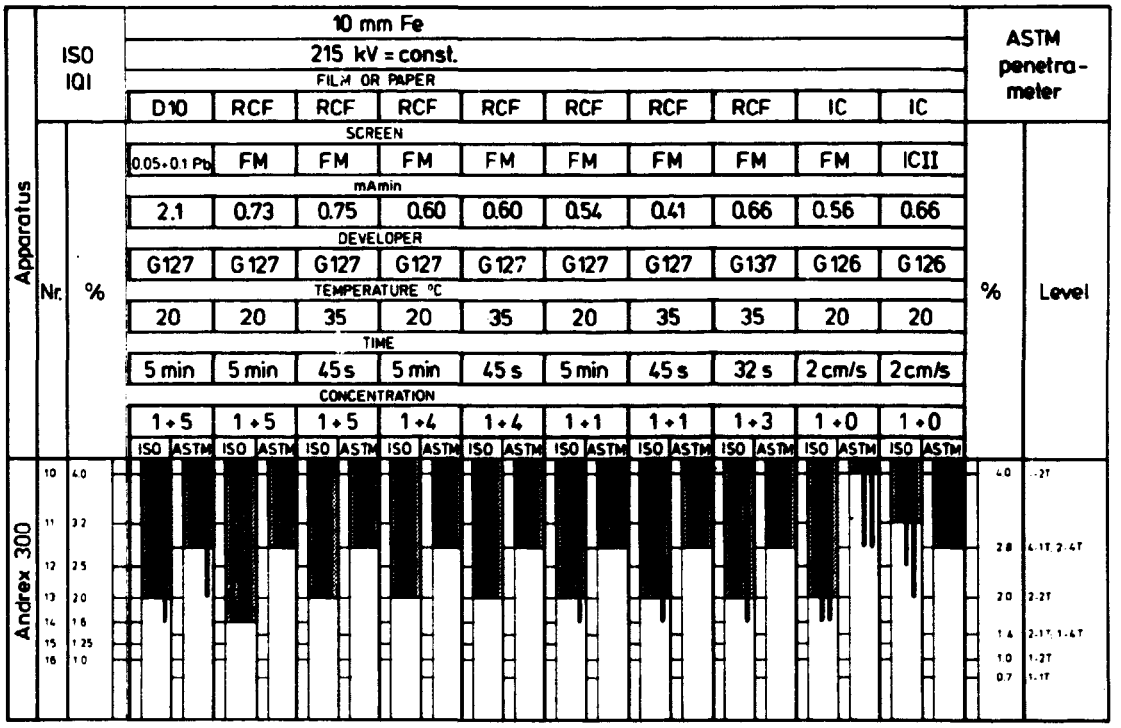


Fig.26. Percent radiographic quality for Agfa-Gevaert fast systems for 10 mm Fe at 215 kV

12. COMPARISON OF WIRE SENSITIVITIES

In |8,9| the results obtained of the investigation of radiographic image quality found for different thicknesses of Al and Fe (10,20 and 30 mm) radiographed at different kilovoltages for Kodak fast systems and the Agfa-Gevaert IC/ICII paper were compared.

This was recently supplemented with the results obtained for Agfa-Gevaert fast systems (D10, RCF, IC/FM), as reported in |3|.

The results of this investigation are presented in figs. 27, 28, 29 for Al and 30, 31 and 32 for Fe.

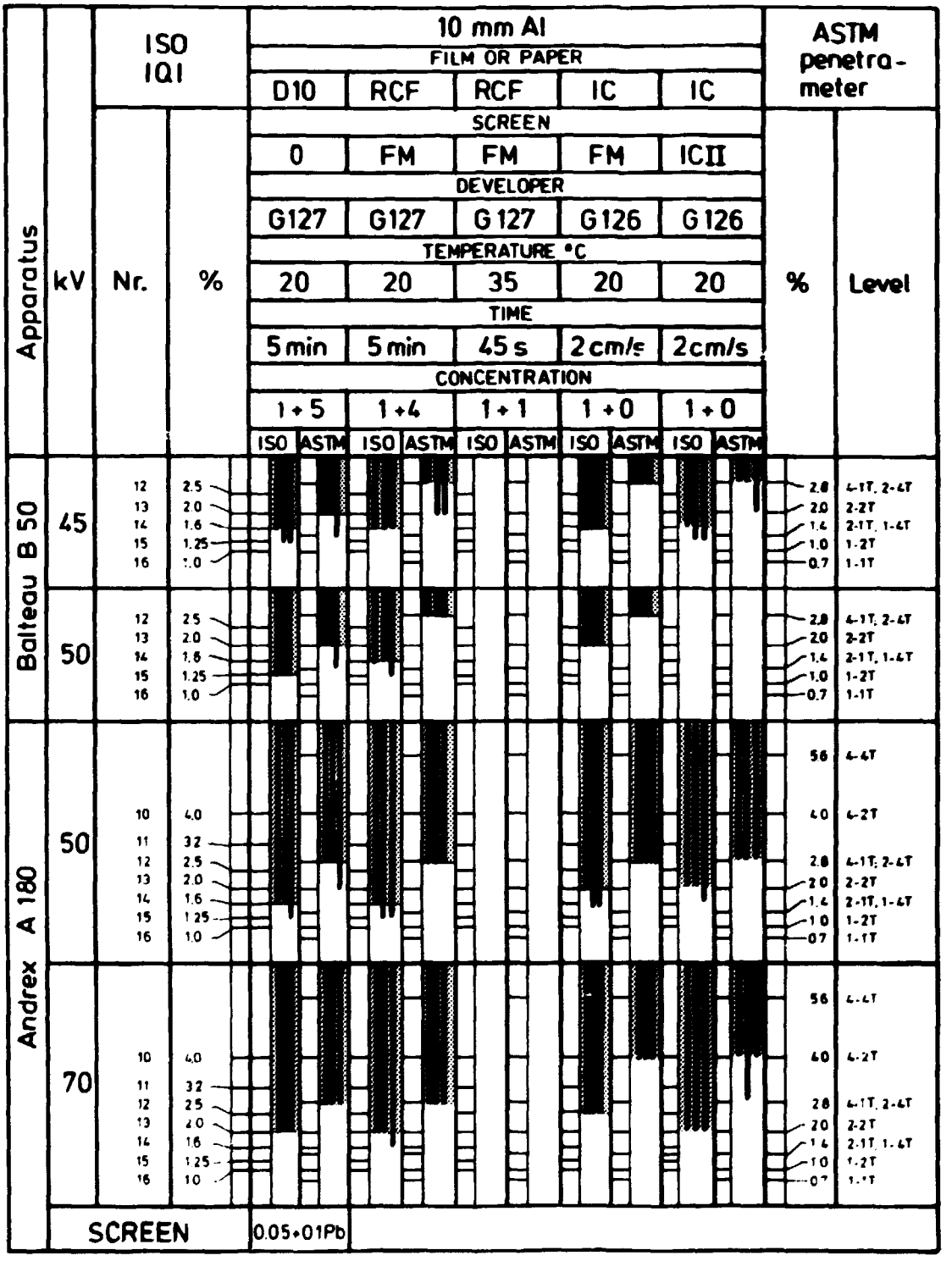


Fig.27. Image quality for 10 mm Al

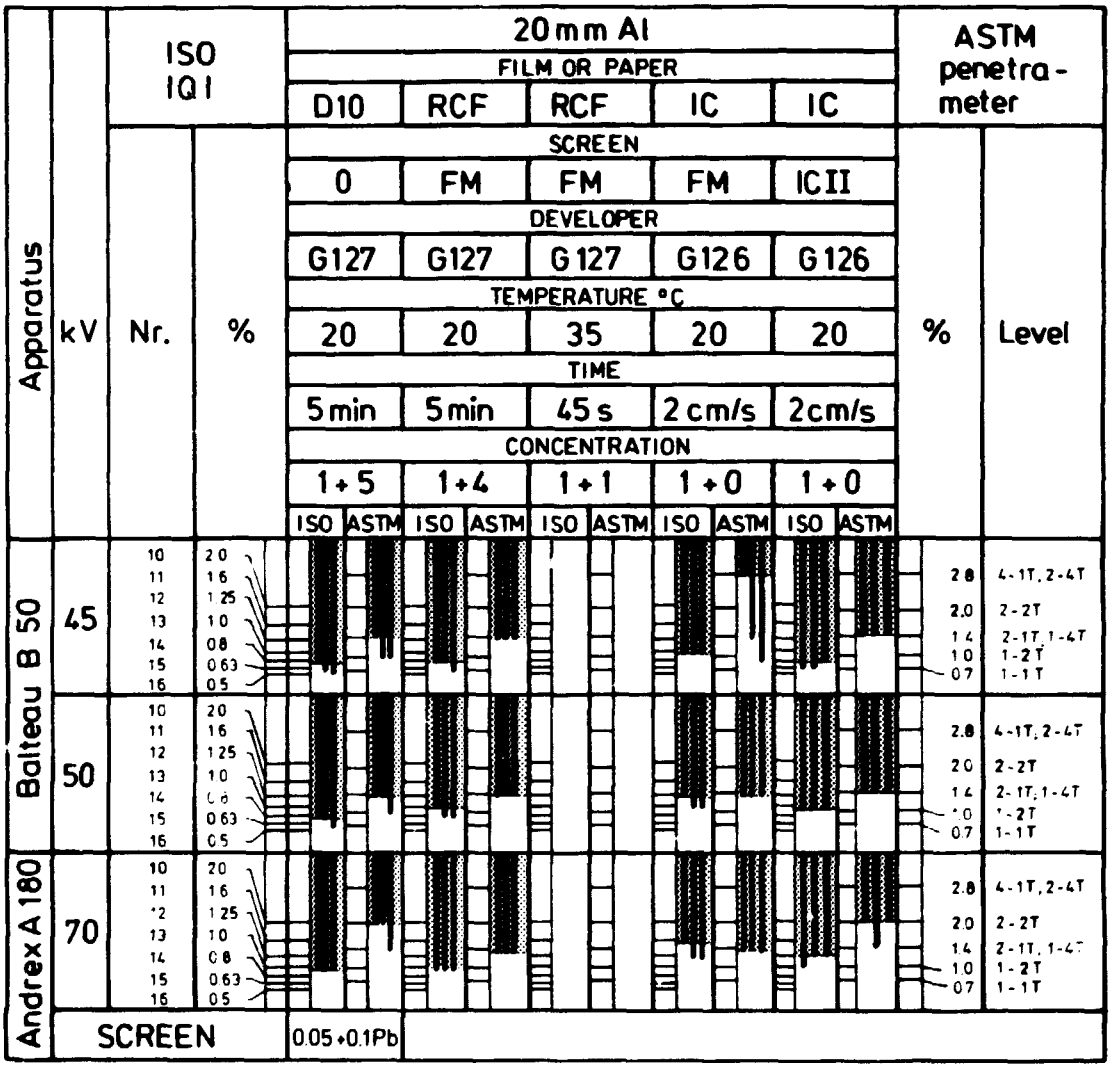


Fig. 28. Image quality for 20 mm Al

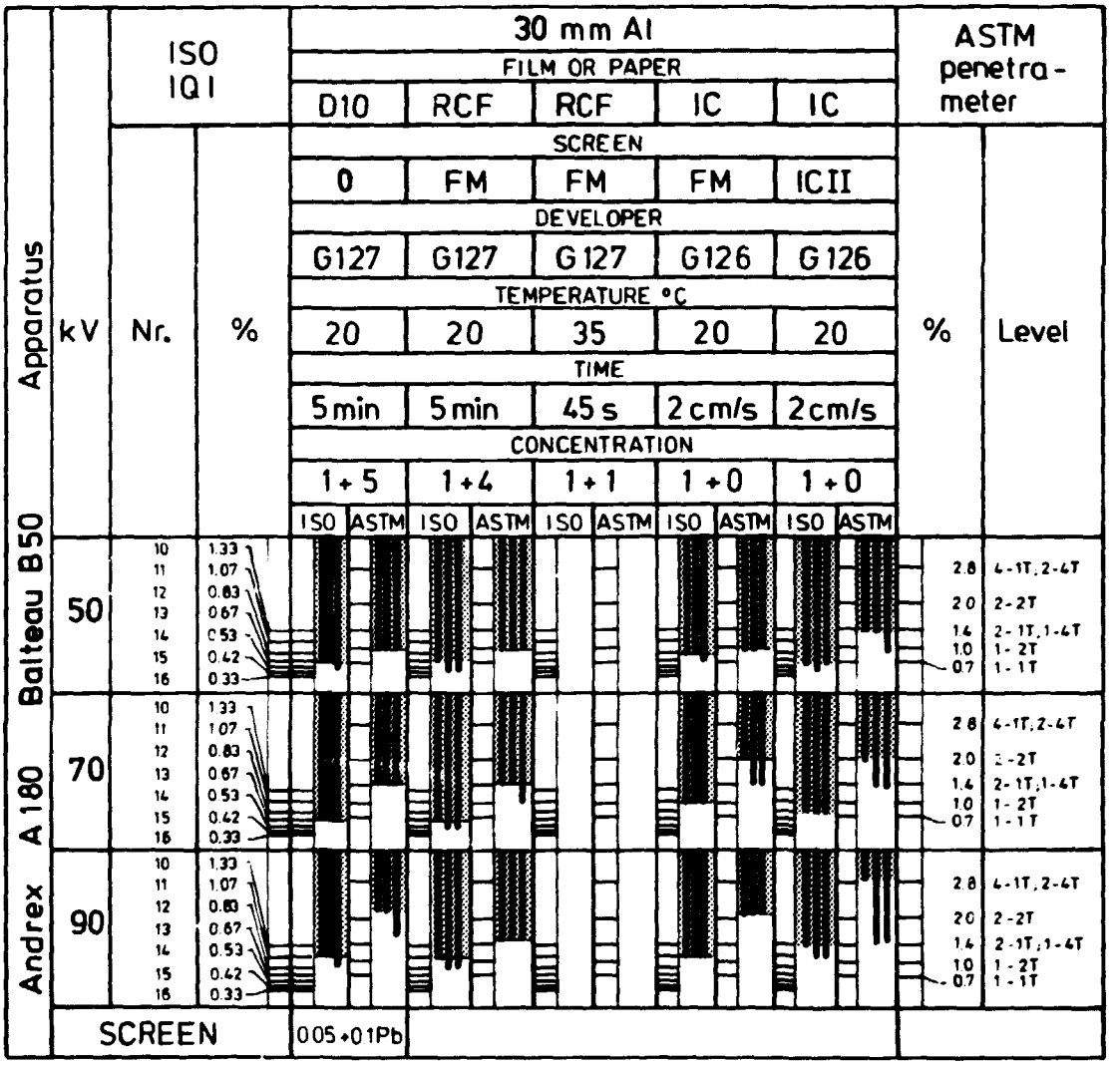


Fig. 29. Image quality for 30 mm Al

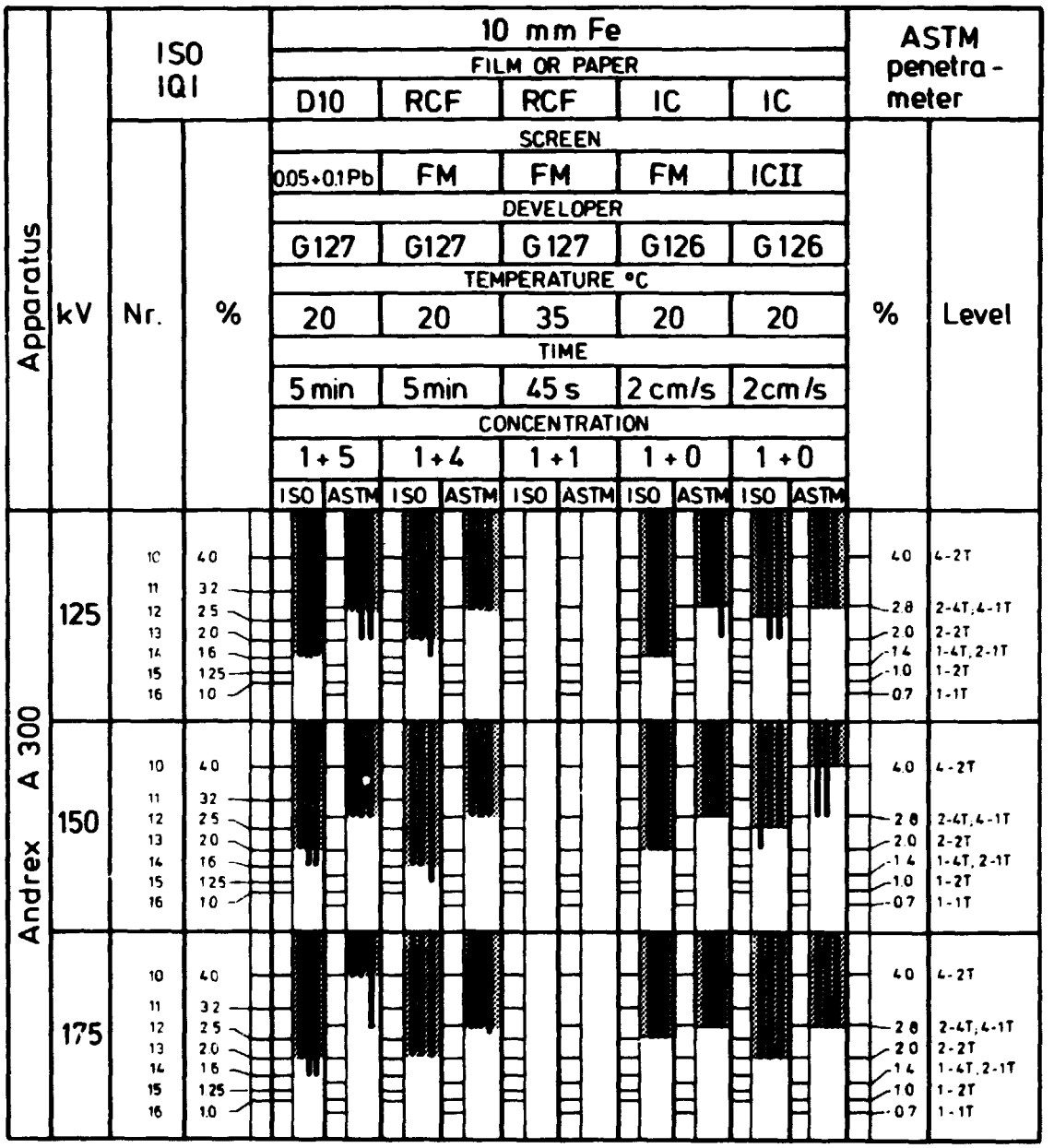


Fig. 30. Image quality for 10 mm Fe

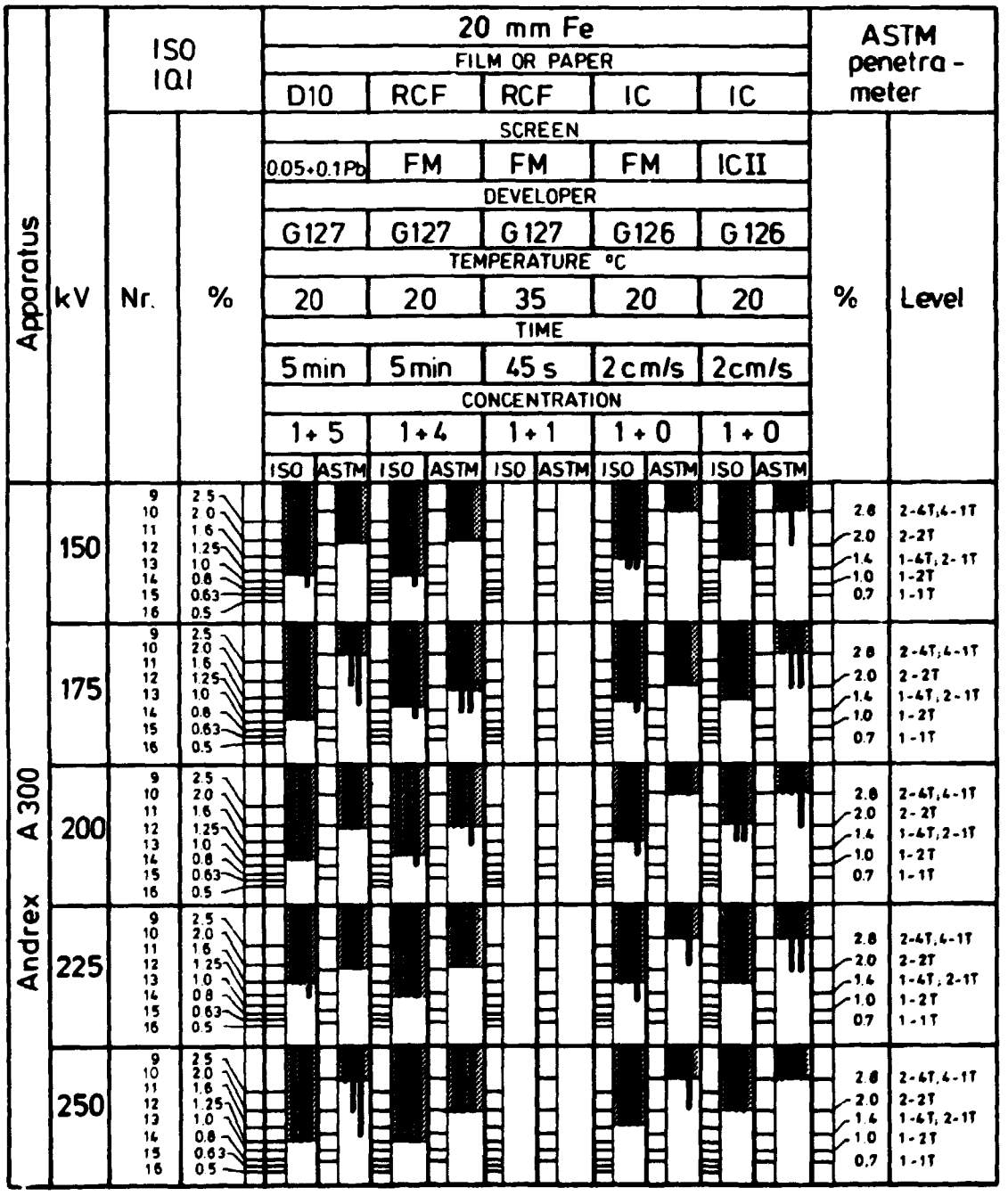


Fig. 31. Image quality for 20 mm Fe

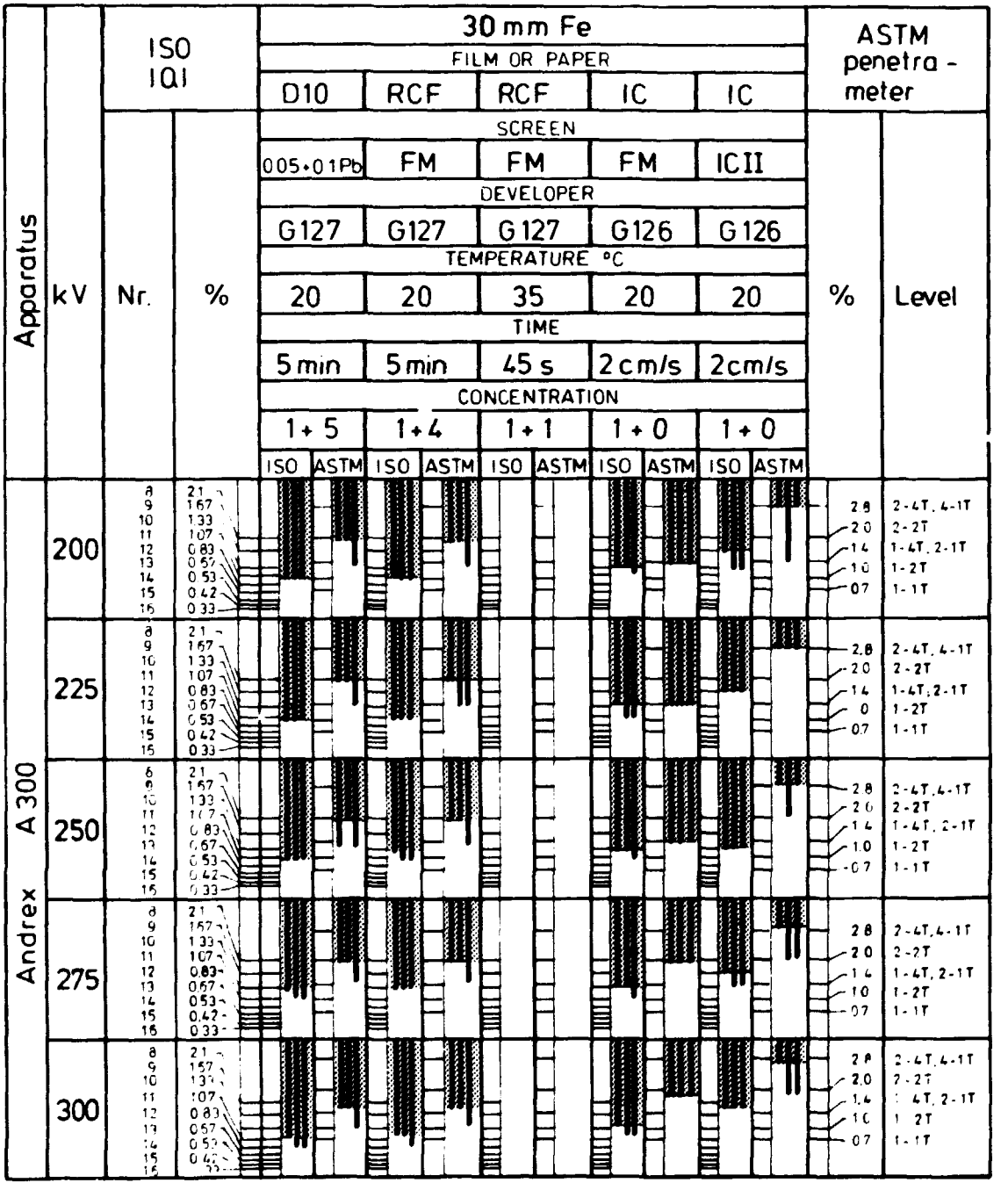


Fig. 32. Image quality for 30 mm Fe

The present comparison is made for results obtained by the constant exposure method.

12.1. Kodak systems

Looking at the results obtained with aluminium at constant exposure (fig. 11) one can see that only the slowest films (SR, DR and M) show the finest wire sensitivity of 0.53%, whereas sensitivities obtained with such papers as 620/F2 and 700/F1 are equal to those obtained with faster films (A, C and D), i.e. 0.67% (one more wire seen on the radiographs).

Looking at the results obtained with aluminium at constant kilovoltage (fig.12) one can see that also here the finest wire sensitivity of 0.53% was reached for the slowest films (SR, DR and M). It decreases considerably for all other fast systems (e.g. for 700/F1 by 3 wires to 1.07%).

By comparing the results obtained by those two methods (constant exposure vs. constant kilovoltage) one can clearly see the advantages of the constant exposure method.

It is, however, remarkable that by both methods a wire sensitivity better than 2% was reached for all Kodak systems.

The results obtained with steel at constant exposure (fig.13) are very similar to those for aluminium. Here also the highest wire sensitivity of 1% was reached for the slowest films (SR, DR and M) and it was possible to reach equal sensitivity of 1.25 % for such papers as 620/F1 as for the faster films A and C (which are worse than the best one for slow films only by one wire). The faster film (D) showed a sensitivity that is worse by two wires (1.6%) which could be reached by all papers (except the 600/F1).

Results obtained with steel at constant kilovoltage show even a greater decrease in the wire sensitivity for faster systems (fig.14). Here only the slowest films (SR and DR) show the best sensitivity of 1%. The sensitivity of the fast systems deteriorates by 4 wires to 2.5% and only occasienally can reach 2%, as in the case of the D film and 700/F2 paper.

Also for steel the advantage of the constant exposure method has been confirmed.

12.2. Agfa-Gevaert systems

While comparing the results obtained for Agfa-Gevaert systems one will look in particular for the processing modes recommended by the manufacturer for the RCF/PM film (manual: M3 - concentration (1 + 4), developing at 20°C for 5 min; M6 - concentration (1 + 1), developing at 35°C for 45 s; automatic: A - concentration (1 + 3), developing at 35°C for 32 s).

From fig. 15 one can see that with aluminium at constant exposure the best wire sensitivity of 0.53% was reached for only the slowest films (D2 and D4), whereas for all the other systems only one less wire (0.67%) was seen.

As described in 12.1. above with aluminium at constant kilovoltage (fig.16) the wire sensitivity decreases considerably with the increase of the speed of the system. The best sensitivity of 0.53% was reached only for the slowest film (D2) and drops by 3 wires (to 1.07%) for the RCF film processed with the M3 and M6 mode and even to 1.33% for D10 film and IC paper.

As would be expected also here the advantage of the constant exposure technique was confirmed.

With steel at constant exposure (fig.17) the best wire sensitivity of 1.25% was reached for only the slowest D2 film (although 2 of 3 observers could see the 1% wire). The same high sensitivity could be reached by the RCP film (M6), whereas for all other systems a sensitivity poorer by only one wire (1.6%) was reached (except for IC/ICII - two wires, 2%).

With steel at constant kilovoltage (fig.18) again the same effect was observed as before: only the slowest film (D2) shows the finest wire sensitivity (1.25%) which thereafter decreases by two wires to 2% (except for IC/ICII - 3.2%).

For all Agfa-Gevaert Systems a wire sensitivity better than 2% could be reached both for Al and Fe (with the single exception of IC/ICII and Fe at constant kV).

13. COMPARISON OF RELATIVE SPEED AND KILOVOLTAGE

In 9 above, relative speed and kilovoltage were given separately for Kodak (figs.4 and 5) and Agfa-Gevaert (figs. 6 and 7) systems. The relative speed was calculated for 170 kV for Al and 215 kV for Fe, whereas the relative kilovoltage for 25 mAmin for Al and 100 mAmin for Fe. In all instances the comparison was made at constant film density of $D_f = 2.5$ and paper density of $D_p = 1.0$.

Now all Kodak and Agfa-Gevaert systems will be compared together. The result is shown in tables 1 and 2 for the relative speed and tables 3 and 4 for the relative reduction in kilovoltage.

Table 1. Comparison of relative speed for 30 mm Al at 170 kV

Film/paper	Screen	Relative speed
SR	0.05+0.10mm Pb	1
D2	0.05+0.10mm Pb	1
DR	0.05+0.10mm Pb	1.3
M	0.05+o.10mm Pb	3.7
D4	0.05+0.10mm Pb	4.55
D5	0.05+0.10mm Pb	6.94
D7	0.05+0.10mm Pb	13.5
A	0.05+0.10mm Pb	17
C	0.05+0.10mm Pb	20
600	F2	30
700	F2	34
D	0.05+0.10mm Pb	44
D10	0.05+0.10mm Pb	45.5
620	F2	81
RCF (M3)	PM	114
RCF (A)	PM	114
IC	PM	147
IC	IC II	180
RCF (M6)	PM	185
700	P1	192
600	P1	313
620	P1	625

Table 2. Comparison of relative speed for 10 mm Fe at 215 kV

Film/paper	Screen	Relative speed
SR	0.05+0.10mm Pb	1
D2	0.05+0.10mm Pb	1.11
DR	0.05+0.10mm Pb	1.25
M	0.05+0.10mm Pb	3.33
D4	0.05+0.10mm Pb	5
D5	0.05+0.10mm Pb	8
A	0.05+0.10mm Pb	13
D7	0.05+0.10mm Pb	15
C	0.05+0.10mm Pb	17
700	F2	22
600	F2	22
D	0.05+0.10mm Pb	33
D10	0.05+0.10mm Pb	48
620	F2	60
700	F1	85
600	F1	122
RCF (A)	FM	151
IC	IC II	151
RCF (M3)	FM	166
IC	FM	178
RCF (M6)	FM	244
620	F1	303

Table 3. Comparison of relative reduction in kilovoltage for 30 mm Al at 25 mAmin

Film/paper	Screen	% kV
SR	0.05+0.10mm Pb	100
D2	0.05+0.10mm Pb	100
DR	0.05+0.10mm Pb	94
M	0.05+0.10mm Pb	71
D4	0.05+0.10mm Pb	62.4
D5	0.05+0.10mm Pb	55.3
D7	0.05+0.10mm Pb	53.5
A	0.05+0.10mm Pb	50
D	0.05+0.10mm Pb	44
C	0.05+0.10mm Pb	45
D10	0.05+0.10mm Pb	44.1
700	F2	44
600	F2	44
620	F2	40
RCF (M3)	FM	39.7
RCF (A)	FM	39.7
IC	IC II	38.8
700	F1	38
RCF (M6)	FM	37.6
600	F1	37
IC	FM	36.8
620	F1	36

Table 4. Comparison of relative reduction in kilovoltage for 10mm Fe at 100 mAmin

Film/paper	Screen	%kV
SR	0.05+0.10mm Pb	100
D2	0.05+0.10mm Pb	98
DR	0.05+0.10mm Pb	88
M	0.05+0.10mm Pb	77
D4	0.05+0.10mm Pb	71
D5	0.05+0.10mm Pb	66
A	0.05+0.10mm Pb	63
D7	0.05+0.10mm Pb	61
C	0.05+0.10mm Pb	61
700	F2	59
600	F2	59
D	0.05+0.10mm Pb	56
D10	0.05+0.10mm Pb	55
620	F2	54
RCF (A)	FM	53
RCF (M3)	FM	52
700	F1	52
600	F1	52
IC	IC II	52
RCF (M6)	FM	52
IC	FM	51
620	F1	50

On analysing the results presented in tables 1 and 2 one can see that the relative speed for X-ray films exposed with lead intensifying screens is almost the same for Al and Fe, though they were exposed at different kilovoltages through different filters. Although the 170- kV X-rays, filtered through 0.05 mm Pb (front intensifying screen) and 30 mm Al lose more intensity than the 215-kV X-rays filtered through 0.05 mm Pb and 10 mm Fe, but this loss is compensated for by the higher sensitivity of the X-ray film to softer X-rays.

For the RCF film with fluorometallic screens the relative speed is higher for 215-kV X-rays filtered through 10 mm Fe than for 170 kV and 30 mm Al. This can, perhaps, be explained by the relatively higher intensification factor of the fluorometallic screens than lead screens.

For radiographic paper exposed with fluoroscent intensifying screens the relative speed is much higher for 170 kV and 30 mm Al than for 215 kV and 10 mm Fe (with the exception of the IC paper exposed with fluorometallic screen). This is, no doubt, caused by the decrease of the intensification of the fluoroscent screens with increasing radiation energy (as shown, e.g. in [1]).

Performing a similar analysis for tables 3 and 4 one can reach to the following conclusions about the relative reduction in kilovoltages: For X-ray films exposed with lead intensifying screens relatively higher kilovoltage is required for films with increasing speed. This is also true for the RCF film and radiographic paper. This means that although the attenuation of 170 kV X-rays in 30 mm Al will be higher than those of 215 kV and 10 mm Fe, the higher sensitivity of X-ray films and papers for lower energy radiation will compensate for that effect.

To be able to formulate more precisely the conclusions about the relative sensitivities of different radiographic systems in relation to such factors as radiation energy, attenuation

in different materials and intensification factors of different intensifying screens a more extensive investigation is needed, based not only on theoretical considerations but also on actual measurements.

14. CONCLUSIONS

1) With all fast radiographic systems, analysed in the present investigation, a wire sensitivity better than 2% can be achieved if the kilovoltage is chosen properly.

2) The advantages of the fast radiographic systems can be best prooved for soft X-rays and light materials (e.g. Al).

3) A very considerable reduction of exposure and kilovoltage can be obtained when using films with fluorometallic screens or papers with fluorescent or fluorometallic screens. Other advantages of fast radiographic systems (as enumerated in 4 above) are also of great practical importance.

4) The constant exposure technique was shown to be very useful in assessing the advantages of the use of fast radiographic systems. It gave similar results to those obtained by more conventional methods (presented, e.g. in [3]) .

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ASSESSMENT OF FAST RADIOGRAPHIC SYSTEMS BY THE CONSTANT EXPOSURE TECHNIQUE

by

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METALLURGY

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54 pages + 4 tables + 32 illustrations

Abstract

The constant exposure technique was applied to compare the radiographic image quality and relative speed of different fast radiographic systems. Conventional industrial X-ray films, exposed with lead intensifying screens, special fast film with fluorometallic screens as well as different brands of radiographic paper exposed both with fluorescent as well as fluorometallic screens were tested and compared. ISO wire IQI's and ASTM penetrameters were used together with 30-mm aluminium and 10-mm steel plates. For all the fast radiographic systems wire sensitivity better than 2% was obtained.
The constant exposure technique proved to be adequate for the assessment of fast radiographic systems.

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